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IMPACTS OF END-USER COMPUTING
ON THE STRUCTURE OF
CONTEMPORARY ADMINISTRATIVE ORGANIZATIONS

by

Paul Bernard Gashler

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Thesis Advisor: T. K. Abdel-Hamid

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Impacts of End-User Computing on the Structure of Contemporary Administrative Organizations

by

Paul B. Gashler
Commander, Royal Australian Navy

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ABSTRACT

End-user computing (EUC) places information processing power in the hands of people at all levels of organization. With information now widely accepted as a corporate resource, the impact of distributed EUC on organizations is potentially very significant. This thesis examines, via case studies, EUC impact on the structure of contemporary administrative organizations, emphasizing three structural variables - information processing, differentiation of organizational groups and communications networks. EUC has been shown both to instigate and facilitate structural change in the organizations studied. The impacts noted in the cases are listed by structural variable. Interpretations of the case study results are also provided.

TABLE OF CONTENTS

I. INTRODUCTION

A. BACKGROUND

End-user computing (EUC) has been defined [Ref. 1: p. 283] as: "the use of computer-based tools by anyone outside the formal data processing or information systems area to support his or her work".

This definition recognizes a significant shift in the application of corporate computing resources, over the past decade, from centralized mainframe and mini-computer environments to a new mix of de-centralized systems operating under the direct control of their users. Also recognized is that 'users' do not exist only at the end of an organizational chain, but may be persons at any level performing any management or administrative task.

Information is now widely accepted as a corporate resource. Increasing corporate competition, a climate of decreasing commercial margins and constrained budgets all demand faster and better-quality decisions. Of the many administrative organizations that have installed user-level computing systems - including standalone and networked personal computers, decentralized database management systems, micro to mainframe links and electronic mail - in an attempt to become more effective, some have embraced EUC with management success, and others appear to have

allowed applications to proliferate without recognizable gain to organizational goals. So there is a wide range of environments that may be taken into account in this thesis, some implementing EUC in response to a defined corporate strategic goal and some acting for other reasons.

B. OBJECTIVES

This study researches a sample of large corporations, to judge the extent that end-user computing causes or catalyzes change in their structure. This view is taken at a deliberately high level, with emphasis on the strategic implications of EUC on organizational change.

Past research appears to have emphasized either technical computing or organizational design aspects of the end-user situation. This study takes the different approach of examining both information technology and organizational issues together, aiming to create a balanced view of both of these variables in the evolution of contemporary administrative organizational structures.

C. THE RESEARCH QUESTIONS

The **primary research** question is:

> What **are** the impacts of end-user computing on the structure of contemporary administrative organizations?

Amplifying the primary question are the following:

- Does end-user computing instigate structural change in organizations or facilitate it?

- To what extent do organizational structures change when new information technology is introduced to end-users?

These secondary questions address structural impacts from the view of cause and effect, helping to focus research on a comparison of current effects against the established foundations of organizational theory and past research results.

D. SCOPE AND LIMITATIONS

Both scope and limitations of this study are covered in detail in Chapter III. A brief overview is given here.

1. Scope of the study

Research for this thesis was conducted in the administrative branches of three large, complex organizations. Each of the organizations has a different perspective on the use of information technology, and EUC in particular, to support administrative operations and the mesh of results from these differing perspectives is considered desirable in assessing the impacts of EUC on organizational structure.

Concentration on administrative organizations in the sample allowed case studies to look at different aspects of end-user computing technology, including office automation, database management and telecommunications, as overlays to the classical data processing environment. This is not to lessen the importance of end-user issues in engineering and production environments, but simply to

recognize that the whole field is too wide to be covered effectively in this one study.

2. <u>Limitations of the study</u>

The limitations of the methodology followed in the thesis are:

- the case study approach limits the researcher's control over the conditions of his investigations;
- the anecdotal nature of the evidence suggests that subjectivity may be present in this study;
- time available for this thesis limited the size of the sample, and
- all of the organizations studied are large, precluding the effects of EUC on the structure of medium-sized and small organizations from being appreciated.

E. SUMMARY OF FINDINGS

The impacts of EUC on organizational structure are summarized in Table 9 of Chapter IV. These impacts include:

- variations in hierarchical levels, with reductions through improved information processing, and additions through new support layers;
- elimination of sections of middle management and supervisory layers, through improved information processing and designed information channels;
- re-centralization of certain parts of the organization through improved task performance and information flow;
- increasing spans of control, sometimes supporting removal of middle management layers, and sometimes following addition of new tasks without need for additional management hierarchy;
- interorganizational linkage, and
- increase in the importance of informal structures.

F. OUTLINE OF THIS THESIS

A detailed review of the literature covering both information technology and organization structure was conducted in Chapter II. This review created a high-level perspective of EUC as it evolved from classical management information systems and then established a series of views of contemporary organization structural theory. Finally in Chapter II, published research was used to show the degree of coupling that exists between information technology and structure, that might be expected to be repeated in today's research on end-user computing.

Chapter III provides the link between the prior research base of Chapter II and the direct research of Chapter IV. The research methodology and its limitations are discussed, together with background to the selection of the direct research sample and details of the case study interviews.

The results of direct research in three large, complex organizations are provided in Chapter IV. This chapter addresses a series of interviews and discussions with managers having direct responsibility for information in their organizations and for EUC, and with internal specialists in organizational design. The view taken during these discussions was deliberately high-level, so that a layered, strategic outlook could be achieved from study of the three organizations.

Finally, Chapter V interprets these results and answers the research questions of this thesis. Also identified are areas where further research would appear to be beneficial.

G. THE VALUE OF THIS STUDY

Because of the dual approach taken in this thesis - technical and organizational - the results should provide a better foundation than currently exists for managers, particularly at higher levels, to appreciate the relationships between EUC and the structure of administrative organizations. Further, this study may suggest ways for improved application of end-user tools to the corporate administrative process, and may point to a greater range of options for structural change that may be considered by senior managers in large administrative organizations.

II. OBSERVATIONS FROM PRIOR RESEARCH

A. OUTLINE

This chapter will examine the literature to establish a foundation upon which to base the later direct research.

The following sequence is used:

B - review of the evolution of EUC and the computing tools available to end-users;

C - review of organizational structure theory, focusing on three major factors affecting organizational structures: information processing, differentiation of working groups and communications networks;

D - reported impacts of EUC on organizational structure, noted in prior research.

B. THE EVOLUTION OF END-USER COMPUTING

1. Definitions

End-user computing is a relatively new term to explain a situation with origins in the 1970s. There appears to be no single definition, but the range of views of EUC can be represented by the following three from Rockart and Bullen, the IBM Corporation and Ball respectively:

- The use of computer-based tools by anyone outside of the formal data processing or information systems area to support his or her work. [Ref. 1:p. 283],

- The direct use of data, tools and services by business people to meet business needs as extensions of corporate information and data requirements. [Ref. 2].

- Any use of a traditional MIS-developed system accessed by a terminal. [Ref. 3]

Each of these definitions addresses people operating computer applications outside of the 'classical', centralized information systems environment. EUC therefore implies decentralization of processes to the end-user work area. These processes may still be applied by central information systems (IS) management, but are applied remotely by users for their own individual purposes. This decentralization further implies a degree of transparency of EUC applications to central IS managers. Rockart and Bullen expand their own view [Ref. 1:p. 283]:

> This definition includes managers and professionals using personal computers, word processing done by secretaries, time sharing systems used by scientists, and electronic mail used by the CEO, to name a few examples.

There are obvious parallels between these commercially-oriented views of EUC and definitions of 'office automation', such as that of Mowshowitz [Ref. 4]:

> the use of information processing technology in an office environment to create, process, store, retrieve and communicate information in the performance of managerial, professional, technical and administrative tasks,

and this thesis will certainly focus on the structure of corporate office environments. It is recognized, however, that computing end-users are involved in many more applications than just those of the office. Rockart and Flannery [Ref. 5:p. 288-289] make the distinction between:

'indirect' end users who use computers through other people (e.g., an airline passenger requesting a seat through his travel agent); 'intermediate' end users who specify business information for reports they ultimately receive (e.g., marketing personnel); and 'direct' end users who actually use terminals.

This thesis is predominantly concerned with the category of 'direct' end-users, although the environment of EUC for any organization might include all three categories. Looking more closely at these 'direct' end-users, Rockart and Flannery suggest they can be further broken down according to the sort of applications they undertake, by their personal computer skills, and by the degree of support they need [Ref. 5:p. 289]. Therefore we may be looking at people who simply use the computing systems that have been provided, without adding value to the transactions. Alternatively we may see people who have the skills (such as the ability to create programs) to exploit the available systems as users themselves, or as supporters of less skilled users. End-users may be employees of an organization, or they may be external users of an organization's computing services.

The clear implication of these comments is that substantial changes have occurred in technology and in organizations that allow people to use computers for their own personal and local work requirements, either as remote users of central corporate information systems or removed entirely from them. Changes to both computer end-users and

to their organizations, particularly over the past decade, have constituted a revolution in the eyes of many commentators. The structural effect of these changes is the principal focus of this thesis.

2. <u>Three eras of computing</u>

During the 1950s to early 1970s, in what has been characterized by Cash, Mcfarlan, McKenny and Vitale as the first era of information technology , data processing operated as a "regulated monopoly" [Ref. 6:p. 9]. Mainframe, batch processing systems provided all corporate computing from central facilities, which were both centrally funded and managed. Users obtained indirect access to systems and expertise through their central facility only.

In a recent article, Watson and Carr [Ref. 7] contend that the first end-users appeared in the 1960s. These were people who worked:

> in engineering, where direct access to the computer made it possible to avoid the delays and backlogs of formal development. Engineering departments had a well-defined organizational structure and charter, an established power base, access to financial resources and trained personnel, and could often acquire their own equipment. The engineers also had the aptitude and inclination to support themselves.

During the second era, from early to late 1970s, user involvement was enhanced by timesharing, by which users were allowed direct interaction with central computing resources from remote terminals, and by significant increases in processing productivity through on-line data

storage, faster processors and improvements in operating system software. Data became information more readily. The advent of minicomputers began decentralizing computing resources themselves from a single location to several departmental processing points. Users became more visible in corporate computing information flows, but development and control of these systems remained with professional data processing (DP) management.

There was a general trend to user disenchantment with centralized MIS facilities during this era. As computer sites proliferated and as maintenance and development loads increased, MIS staff shortages developed. The evolution of corporate management information systems had, by the mid 1970s, made data processing more decision-oriented. Accessibility to information and its distribution became issues as information became more important as a corporate resource. With users requiring greater system responsiveness, seeking both new systems and enhancements to existing ones, and with consistent backlogs constraining centralized MIS support, the scene was set for users to take advantage of emerging microprocessor technology.

Microprocessor-based computing was initially limited to computer hobbyists, often themselves experienced DP professionals, who were able to carry out simple functions on small, often portable machines that had previously been

limited to larger, less accessible facilities . As the power of microcomputers grew, and as application software evolved from specialist technology applications (e.g. increasing the utility of primary storage addressing) to general business-related packages (e.g. electronic financial spreadsheets and word processing), the microcomputer became a marketable commodity for increasingly business-like applications at the user level.

Watson and Carr point out [Ref. 7] that:

> business oriented EUC did not appear until the 1970s. At this point, the backlog of requests was intolerable, hardware and software advances were such that business end users were better able to address their own needs and colleges were producing more computer literate graduates. Even so, business oriented EUC did not advance rapidly due to the nature of the end users. They often did not have the attitude, aptitude and training to support themselves as did the engineers.

This comment will become more relevant in later review of Nolan's work on assimilation of computing technology into organizations.

Many commentators peg the introduction of the IBM Personal Computer (PC) in 1981 as the true start of EUC so in evidence today. Although word processing and spreadsheet applications had previously been available on other microprocessor-based machines, the IBM PC was aggressively marketed specifically for business applications. Its open architecture allowed easy upgrade at relatively little cost, giving users significant local computing power, previously available only through systems controlled by external MIS

organizations. Throughout the early to mid 1980s, users at all levels of commercial organizations have been able to access personal computing resources, to tailor software to their own needs and, in very short periods compared to MIS development lead times, to implement effective standalone applications. Initially enhancements in business performance were focused on individual users, but group applications have been more prevalent over the past four years, as networking technology and standards have improved.

The visible and growing population of cheap, general purpose microcomputer application software packages catalyzed improvements in accessibility and utility of minicomputer and mainframe systems, but at a lesser pace. Again, Watson and Carr [Ref. 7] comment that:

> not all users gained access and support through the usual path to the firm's computer. Many sought faster routes through the purchase of packaged software, the use of outside timesharing services, and the departmental purchase of personal computers. In each case, the users' objective was to gain access to the computer and computer-resident data to make queries, analyze data, and generate reports.

We have seen that rapid advances in microprocessor, telecommunication, data storage and data management technologies have sparked a revolution in the way that computer resources are applied in all areas of business. Cash et al [Ref. 6:p. 10] suggest that a third era of information technology is now in progress where, having become more educated to the power and potential of

electronic data processing improving business processes, users are tending to dominate the corporate data processing environment.

This trend better supports the IBM Corporation and Ball definitions of EUC than that of Rockart and Bullen. End-users are becoming considered as primary elements of the total computing process, with information technology taking its rightful place as a tool to improve both system and user performance.

3. <u>Changes in corporate operating environments</u>

As technology has presented opportunities for new computing applications in organizations, the operating environment of corporations has itself been changing. Many of the factors influencing the growth of EUC can be explained by these trends.

Contemporary business is highly competitive, and all commercial organizations are subject to the pressures of the markets in which they operate. A revolution in telecommunications since the 1940s has played a significant part in expanding national and international contacts. Markets for goods are becoming global rather than local. Growth of world markets and persistent inflationary trends have emphasized the relative strengths and weaknesses of commercial organizations in these markets and have put pressure on selling prices and therefore on the cost of goods sold. Commercial margins have been cut to maintain

competitive market position. A common approach to lowering fixed costs has been to reduce administrative staffing, but with increased productivity needed of the remaining workforce. In this operating environment, therefore, the need for better information and better quality decisions has increased.

Corporate staffing strategy in the past 15 years (and most particularly over the past 10) has been to seek ways of reducing hierarchies, both vertically and horizontally. In the horizontal context, the desire has been to reduce the number of tasks requiring manual labor and, in the vertical, the goal has been to reduce layers of decision making. In both cases information technology has been applied to the problem to enhance productivity. Clerical tasks of data gathering and sorting have been automated to increase the amount of information available to managers at less cost. Productivity of decision makers has been addressed through increased mechanization of data processing, information distribution and presentation to and between decision makers, and by improving information flow between organizational layers.

Accompanying greater volume of information has come the requirement for improved presentation of important aspects, and filtration of redundant or irrelevant aspects from that which may be critical to a given decision, all

functions that previously were performed by the administrative staff no longer employed.

To improve local contacts with their clients in this competitive environment, corporations have tended to de-centralize both organization and computing resources, and to focus their organization through more product-oriented and geographically-focussed structures, while preserving the centralized corporate hierarchy as a directing force.

All of these approaches have been aimed at reducing decision time and risk, improving the percentage of either correct decisions or at least decisions that contributed to an increase in corporate net income. The emphasis was originally on productivity, on reducing overhead costs and on gaining information to create competitive advantage. It is apparent that, while information technology has contributed to the achievement of these goals, implementation of the technology at end-user level has brought significant increases in system complexity, particularly in the control and co-ordination of technology, information and people. Clearly there is a need for all three to be managed as an integrated whole.

Greater computing power has brought significant increases in the quantity of data available to users. The relevance of data becomes more important in this situation, mandating faster processing to improve a decision maker's ability to detect relevant and important aspects within the

time available. The availability of information has allowed decision times to reduce but the quality of corporate decision making is often still criticized. This would indicate that better presentation of information and more coherent stratification of options are needed to reduce decision risk. The imbalance between the technology available to end-users and the techniques used to fully exploit the technology is a recurrent theme in contemporary papers on computing in contemporary corporations.

4. Rapid evolution of EUC technologies

The increase in power of hardware and software available to users has blurred the traditional lines of demarcation between microcomputers, minicomputers and mainframes. In the early 1980s, from the hardware view, it was reasonable to differentiate mainframe, mini- and microcomputers on the basis of processing power and price. Such distinctions appear increasingly difficult to apply as the power of processors and peripherals improves, and as the lower-level machines cross increasingly into the capability of higher levels. It is no longer as simple as saying that minicomputers are increasing in capability for a given price range, or that microcomputers are now capable of many of the functions of minicomputers of only a few years ago but at a fraction of the price. Rather it is more common to see some of the characteristics of mainframe and midrange systems (as minicomputers should more rightfully be termed) starting to

appear in microcomputers. Increasing power of microprocessor architecture, catalyzed by very large scale integration and parallel processing, is leading to processing environments on a desktop that rival the power of much larger and more complex machines. Equally significant steps in data storage technology (such as Winchester hard disks and CD-ROM) and decreasing costs per byte stored, now allow departmental data to be located, as required, remote from hitherto specialist large-scale storage sites.

Personal microcomputers are being placed in the hands of users in remarkable quantities, calling for high levels of investment. Robert I. Benjamin, a former senior officer of Xerox Corporation, was quoted [Ref. 5:p. 287] as predicting: "by 1990, EUC will absorb 75% of the corporate computer resource".

Recently, a three-year Air Force contract for the purchase of approximately 90,000 microcomputers was found, just two years into the contract, to have been the ordering vehicle for more than 225,000 systems at a cost of $661 million [Ref. 8]. The report estimated that a further 150,000 microcomputers worth $443 million would be ordered in the third year of the contract. Whether EUC has reached the Benjamin prediction is perhaps less important than the simple reality that, with the numbers of powerful and widely applicable machines being placed in user hands, it is a

force that has great significance for managers and for the ways corporations organize.

Under user control, microcomputer-based applications have been able to achieve de-centralization of process, data and control from central MIS systems. This has created as many inefficiencies in information processing as it has improved decision making, and has led to rifts between inexperienced local users and professional information systems staffs, which are only now being addressed.

5. Computing tools available to end-users

This section reviews the range of computing hardware and software now available to end-users, as seen through users' own eyes (for that is the focus of later direct research). The aim here is to define the general capabilities of EUC tools so that their potential for impact on organizational structure can be appreciated. It is considered necessary to define the 'high end' of capability in order that later research can establish some estimate of the level of usage of available end-user resources in individual corporate cases.

a. Hardware tools

Mainframe, midrange and microcomputers form the triad of computing hardware accessible to end-users. The range of interface machinery, through which users access the processors, is characterized by timesharing terminals, increasingly intelligent workstations, increasingly capable

microcomputers, and a further group of networked computers with aggregated computing power of very significant dimension. We will address each in turn:

(1) Mainframes. Mainframe computer environments continue to retain their ability to process efficiently and store very large data sets. Processor throughput is in a wide range from 25 to 100 million instructions per second (Mips) in systems with multiple, coupled processors, and a higher-performance class of supercomputer provides thousands of tightly-coupled processors with very much higher than mainframe throughput for specialist numeric work. All mainframe machines are multi-tasking, and multi-user, with significant facilities for data security and recovery from failure.

Traditional timesharing terminals provide access to mainframes and minicomputers. Only the most recent screen presentation systems are able to present other than text on screen, and only basic graphical representations are available on the majority of these terminals in use. While the large-scale processing power of mainframes is available to large numbers of single corporate users through timesharing terminals, the majority of these users see lower level machines with greater applicability to their needs, and are therefore not employing this technology at anything like its capacity. Competition from lower-level EUC resources is bringing improvement of mainframe user

interfaces. Graphics terminals, enhanced color and addressable screens are some examples of technology, freely available in microcomputer systems, that have recently been applied to mainframe environments, to make them more attractive to corporate users.

Despite these developments, corporate mainframes still operate often away from the end-user arena. These machines continue to be used in storage and manipulation of large, central databases which tend to be available to end-users indirectly through networks of smaller machines that regulate data flow through the corporate hierarchy.

(2) Minicomputers. In the midrange of corporate computing, so-called minicomputers provide the bulk of departmental data processing. They combine many of the multi-tasking, multi-user, security and recovery attributes of mainframes, with less capacity but with significantly reduced prime and life-cycle costs. Operating originally 16-bit and now generally 32-bit processors, with throughput in the range from 5-30 Mips, minicomputers have historically operated as timesharing devices with dumb terminals attached. However, more recent applications have used minicomputers alone or with mainframes as file servers for networked workstations or as communications controllers for complex networks of processors of all levels. The processing power of contemporary networked minicomputers and

workstations is often in excess of mainframe levels, at a fraction of the cost.

Minicomputers share with mainframe computers a common evolutionary heritage, that of development under professional IS direction. This applies to software development and system maintenance, and generally this has not been the province of end-users. Recalling the comments of Watson and Carr earlier, this lack of intimate involvement with midrange computer operations is part of the hesitancy of most end-users to use other than microcomputers for work where ease of operation is needed.

(3) Workstations. Originally defined as minimally intelligent terminals (as opposed to 'dumb' timesharing terminals, which had only enough memory to support the presentation of information on the terminal screen), the term 'workstation' is now used to describe a growing range of powerful 32-bit, microprocessor-based, multi-tasking and single-user machines, operating at speeds in the range of 5-20 Mips under operating systems such as UNIX. These machines were developed for engineering applications such as computer-aided design (CAD), but their power and increasingly competitive price is now making them attractive for administrative applications such as decision support systems and financial analysis. Minicomputers and mainframes are used as file servers to workstations which most commonly are linked in multi-node networks, thus

providing groups of users with concentrations of high local processing power.

This definition of workstation could also be applied to PC machines operating as intelligent terminals. As multi-tasking, multi-user operating systems like UNIX have not, until very recently, been available to PCs, the trend has been to exclude these lower-level machines from the contemporary workstation definition.

(4) Microcomputers. Single task, single user PCs with 8, 16 or 32-bit processors operating in the range from 100,000 instructions per second to around 4 Mips are today classified as microcomputers. This general definition is very dynamic, and announcements of new products almost daily make the previous high-end definition obsolete. Nevertheless, microcomputers are the backbone of the rapid expansion of EUC because of their high performance for price and relatively low operating costs, and because of the wide variety of easily-used business software available to their users.

(5) Networked computers. Connectivity is a major issue in EUC. All levels of hardware are now able to be networked in local and wide area networks. A revolution in telecommunications over the past two decades has made available a wide range of media. Local Area Network (LAN) hardware ranges from simple telephone line modulator/de-modulators (modems) operating at speeds of up

to 9600 bits per second (bps), through voice-grade, twisted-pair telephone lines at up to 1 million bits per second (Mbps), to coaxial cable Ethernets (3-10 Mbps), data-grade twisted-pair cabled token-ring networks at around 4 Mbps and fiber-optic cabled token-rings now in the 10 Mbps to 80-100 Mbps ranges [Ref. 9]. Data rate is not important in itself as, at these rates, most LANs would exceed the data input/output rates of their host or terminal computers. Rather, the higher the data rate, the larger and the greater the number of files that may be transferred in time acceptable to end-users, and the more terminals that can be accommodated on one network without adverse impact on performance to any individual.

Wide Area Networks (WANs) currently make available high-speed dedicated landlines operating at up to 19,200 bps, long-distance telephone networks in much lower speed ranges but at costs competing with voice rates, interfacing with line-of-sight, satellite or land microwave and also infrared links. Distribution of process, memory, control and, in some cases, data is extending the WAN concept into truly distributed computing systems, particularly in national and international financial networks. International boundaries are being crossed by global networks, although not without attendant legal difficulties.

(6) Secondary storage. Located in the user area as opposed to special storage location, single Winchester hard-disk drives in a personal computer or workstation are today able to store hundreds of megabytes of data at costs in the region of $10-15 per megabyte, and this cost is falling as fast as the storage potential of individual devices is rising. PC-compatible compact disk, read-only memory (CD-ROM) storage devices are currently available for $1000, and their disks are able to store in excess of 500 Mbytes at costs in the range of $5 per megabyte. Secondary storage has ceased to be a concern in the economic design of systems. Hard-disk average seek times are in the range of 10-80 milliseconds and CD-ROM devices currently operate in the 1-2 second range. Clearly, in storage, there is still a trade-off between bytes stored and speed of access.

This plethora of information has been assembled to emphasize the very significant performance of hardware available to end-users. Some of the microcomputer details, for example, could have been the specifications for a mainframe computer of 1978, and the workstation details could have been for a minicomputer of 1983. The aim of this and the following software summary is explain how end-users, historically frustrated by the inability of central MIS departments to satisfy their computing requirements, found increasingly powerful solutions in machines that could be

operated 'on their desktops', and which freed users from the perceived inflexibility of batch and timesharing environments. It is apparent that by no means all the of the available performance of today's computing hardware and software has yet been exploited by users. There is strong evidence that whatever has been applied to date, however, has impacted strongly on the information processing and the commercial performance of administrative organizations generally.

b. Software tools

Computing end-users have available to them, regardless of hardware, a wide range of very powerful software tools, including:

- text processing;
- spreadsheets;
- graphics;
- database management systems;
- statistics;
- modeling, both deterministic and stochastic;
- decision support and expert systems, and
- various presentation interfaces.

All of these tools provide high productivity in comparison with manual methods.

The trend in end-user software is now to integrate tools, and experience shows that end-user applications are not remaining static. Here are some

examples of the present evolutionary state of end-user technology in the corporate administrative world:

- word processing is evolving from text alone to integrated text/graphic environments and desktop publishing;

- single spreadsheets for financial analysis are becoming coupled to relate data in multiple layers;

- complex statistical analysis software has migrated in part from mainframes to microcomputers;

- from use at single terminals, data, text and images are able to be distributed through local and wide-area networks, within and among corporations and internationally, via discrete file transfer packages or via facsimile facilities embedded in the hardware and software of microcomputers;

- liberated from the constraints of telephones systems, voice can now be stored digitally and forwarded on data networks using the same approach as for electronic mail;

- decision support and expert systems are evolving from work in artificial intelligence, from relational database technology and from the science of cybernetics.

This integration process is also linking hardware and software more closely. Therefore, while it is convenient to review end-user computing tools under the above headings of hardware and software, more often than not the two are designed to operate as a single entity.

6. Phases of assimilation of EUC into organizations

In 1979, Nolan [Ref. 10] suggested a six-stage model to address the assimilation of technology in computing organizations, updating the earlier four-stage version by him and Gibson in 1974. The Nolan model has the following components:

- Stage 1: Initiation;
- Stage 2: Rapid expansion;
- Stage 3: Control;
- Stage 4: Development of databases;
- Stage 5: Network development;
- Stage 6: Integration of several functional tools,

and has gained wide acceptance as a general analysis tool, although not without constructive criticism. The Nolan model is still useful in assessing the assimilation of new information technology in administrative organizations today. This view is supported by Cash et al [Ref. 6: p. 260], and Inmon [Ref. 11:p. 11] extends this view particularly to EUC.

The technologies of the original Nolan models have matured and also have changed. Organizations initially made large investments in mainframe computers, and then moved to timesharing systems, both mainframe and minicomputer based, with terminals located in user departments. These types of end-user technologies have passed through the control stage, organizations have evolved structures and systems for their management, and the technologies themselves have stabilized. In general, mainframe and midrange systems are now being operated at satisfactory levels of efficiency with no exceptional strains on their organizational environments.

This mature technology has been overlaid by newer, microcomputer-based systems, which are in the varying stages

of assimilation into organizations. Microcomputers are novel to many organizations and, across all corporations, this technology would appear to be in the range from Nolan's initiation (Stage 1) to development of databases (Stage 4). Rapid expansion of the application software population has made the contagion stage of microcomputer-based EUC more prolonged than was the case for larger machines. This is because of the relative ease with which large numbers of microcomputers and attendant software can be obtained.

Obviously, many of the more recent end-user systems are have not yet reached the robustness and technical maturity of their centralized predecessors. Nolan did not foresee the present meshing of mainframe, minicomputer and microcomputer technologies in an end-user context. A reasonable suggestion is that the relative immaturity of microcomputing constrains the more robust mainframe and minicomputer environments to a range within Stages 1,2,3 and perhaps the early part of Stage 4. In his assessment of the assimilation of EUC into organizations generally, Inmon does not include Stages 3 and 4 [Ref.11:p. 5], but he does qualify his own view by suggesting that the conditions governing the Nolan model and those applying to end-user applications might differ because "the forces of end-user evolution are decelerated or accelerated in different ways" [Ref. 11:p. 7]. For example, growth of networking for microcomputers, and increasing corporate emphasis on

connection of standalone machines into multi-unit systems indicates present trends towards greater control, as in the third stage of the Nolan model.

It is reasonable to accept that EUC has been applied differently from one organization to another, with various organizational factors influencing as much as technical ones. This is apparent in the cases discussed in Chapter IV. The amount of contemporary literature concentrating on adaptation of EUC to contemporary organizations suggests that we are still learning about the technology itself in some cases, still thinking hard about organizational impacts in others, and that we are starting to address problems of management (control and co-ordination particularly) in the remainder. This would support the contention that the introduction of microcomputers into the end-user computing world has reduced the effectiveness of corporate computing, and that management effort will continue to be needed to accommodate the new layer of technology on the old. At the very least, the apparent spread of assimilation between computing layers in an organization, and the variances in assimilation of computing technology between organizations presents problems to managers.

Variance in the degree of assimilation of end-user technology into different organizations implies differences in the type and degree of organizational changes that might be observed, but the factors involved are complex. It may

be that clear trends are difficult to establish by the Nolan framework alone, and other views may be required.

7. Impacts of corporate strategy on EUC growth

In an attempt to enhance the view offered by Nolan, the influence of corporate EUC strategy has been considered. A recent paper by Munro, Huff and Moore [Ref. 12:pp. 5-27] reports on a research study examining strategies for expansion and control of EUC, and provides a systematic approach of value to this thesis. The Munro model looks at EUC strategies through two key questions:

- how quickly should EUC be allowed to grow, and
- what controls should be applied to ensure that EUC remains within defined growth boundaries.

From these questions, four strategic management approaches, combining the constructs of expansion and control, have been identified and are presented in Figure 1. The names in the cells correspond to the thrust of management policy that accompanies a given strategic view.

The four strategic approaches of this matrix were noted by Alavi, Nelson and Weiss [Ref. 13], who then established, through a series of studies, a table of characteristics including the kind of organizational structure liable to exist in organizations following various mixes of expansion and control. Their results are summarized in Table 1.

Figure 1

Four Strategies for End-User Computing Growth

		Low	High
EXPANSION	High	Acceleration	Controlled Growth
	Low	Laissez-faire	Containment
		CONTROL	

[Ref. 12:p. 9]

TABLE 1

CHARACTERISTIC STRUCTURES FOR EUC STRATEGIES

Strategy			
Laissez -faire	Containment	Acceleration	Controlled Growth
No formal structure to control.	MIS department active in containing EUC.	Centralized but active support facilities.	Central planning, standards, monitoring.

[Ref. 13]

Combination of the Munro and Alavi approaches appears to give a sound basis for assessment of corporate strategic approaches to EUC, and therefore will be of value in the case studies presented in Chapter IV.

Having established a view of the evolutionary state of EUC, we will now focus on certain theories of structure that are particularly applicable to the environment of contemporary administrative organizations.

C. ORGANIZATION STRUCTURE THEORY

1. Structure, technology and people

Organizational structure has been described by Miles as "those features of the organization that serve to control or distinguish its parts". [Ref. 14]. In the context of modern business organizations, Ivancevich and Matteson suggest that structure could be referred to as: "a relatively stable framework of jobs and departments that influences the behavior of individuals and groups towards organizational goals". [Ref. 15:p. 470].

The reason organizations exist is to gather together people, their expertise and the tools needed to achieve common goals. We form groups to progress tasks accepted as beyond the skills or capacity of one person, and we design organizations to take form or structure appropriate to the tasks being performed. The study of organizations as structured entities has its origins in the work of

industrial psychologist Frederick Taylor and sociologist Max Weber. Taylor developed the concept of scientific management, a methodology to maximize the utility of time and motion for a given worker. A model of the hierarchical nature of rational bureaucracies was first proposed by Weber and, according to Bolman and Deal, has been a foundation of much organizational research for the past 40 years [Ref.16:pp.30-31].

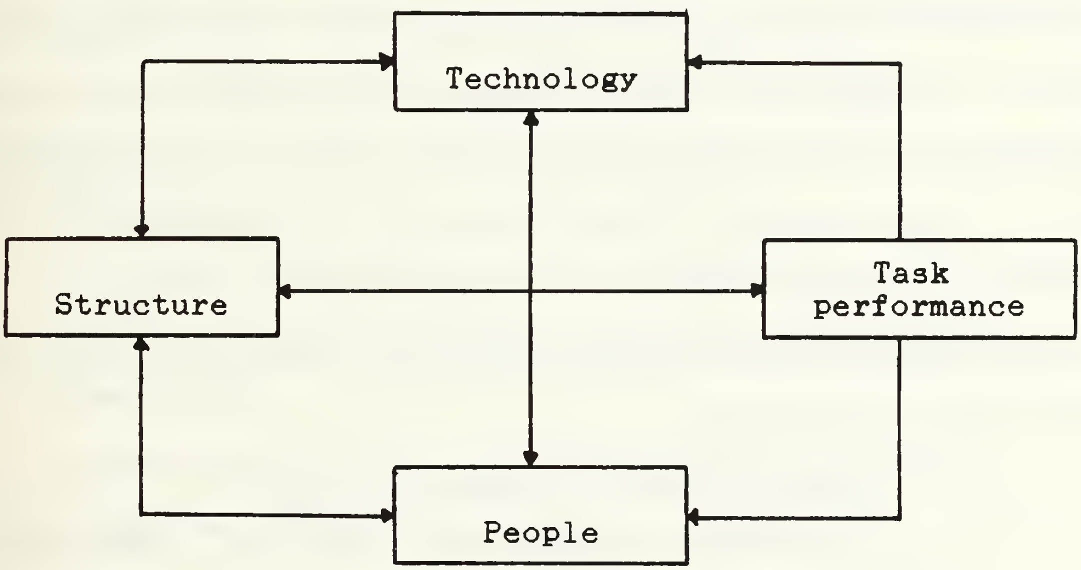
a. <u>Technical, political and cultural influences</u>

According to Kast and Rosenzweig [Ref. 17: pp. 111-113] and also Tichy [Ref. 18:pp. 7-20], organizations are influenced by the interrelationships of technical, political and cultural elements, together with the managerial processes of the organization itself and of the environment in which it operates. Particularly, the process of successful change in organizations appears dependent on a balance among these elements. Sociotechnical research in England during the 1950s and 1960s focussed on the appropriateness of organization to the tasks on hand, the technology available and workforce expectations. Burns and Stalker (1961) established views of the impact of technology on organizations. They distinguished between mechanistic and organic organizational forms and suggested the latter are more appropriate for nonroutine, creative tasks [Ref. 16:p. 195]. In a work that established the contingency theory of organization, Lawrence and Lorsch

[Ref. 19] proposed a model which emphasized the interplay between any major part of an organization and its relevant external environment. A model developed by Harold J. Leavitt [Ref. 20] shows the interaction between the functional elements of organizational performance and the influence of change on these interdependent elements. The model, depicted in Figure 1 below, shows the influence of organizational structure, technology and people on task performance and also the reverse influence of people and technology on structure itself. All elements influence each other.

Figure 2

Interactions in Organisational Change



'People' in this model include power and cultural relationships in an organization, while 'technology' reflects the processes as well as the tools used to carry out tasks, which in the context of this study can well relate to EUC. Leavitt's view is paralleled by Tichy [Ref. 18:p. 119].

All of this research work shows that the effectiveness of people and technology in optimizing task performance depends on the appropriateness of the organizational structure in which they are operating. Conversely, stable organizational structure appears to be achievable when the 'people' and 'technology' elements are in balance. This model should therefore be considered in relation to the previous discussion on assimilation of information technology in organizations. The introduction of new technologies such as microcomputers affects structure directly and indirectly through power and cultural elements. Overall performance of the organization is related to the sum of the effects as in the Leavitt model in Figure 2. This interplay will be seen on several occasions in the case studies in Chapter IV.

b. <u>Organizational Power and Culture</u>

Ivancevich and Matteson [Ref. 15:p. 760] define power as: "the ability to get things done the way that one ants them to be done". A similar approach is taken by Price and Mueller [Ref. 21], with their definition being:

"the production of intended effects by some persons on some other persons". The degree to which the 'intended effects' can be imposed depends on the perception of authority by people receiving direction, and their acceptance of the legitimacy of that authority in the people giving direction.

Power implies 'concentration of authority' and centralization is seen as: "the distribution of decision-making authority through the hierarchy" [Ref. 21]. Therefore power appears most important to any consideration of organizational structure because it contributes to the issue of whether the organization should be centralized or de-centralized, and because, following the Leavitt model, it defines the way in which people at different levels of organization can affect the organization's task performance.

Markus [Ref. 22] addresses the adage, "Information is power", noting that power can be achieved in an organization by:

- obtaining information needed by others for their work;
- having control of a single source of information, and selectively filtering information that is distributed to others, and
- controlling the ways that information is presented.

These examples suggest that access, ownership and control of dissemination of information are key elements in the exercise of power in relation to computer-based information systems. Therefore, introduction of new information systems

could be expected to have a measurable effect on the power relationships in an organization. If previously centralized management information systems are replaced by more decentralized end-user systems, then changes in access, revisions to formal or informal ownership of data, and new abilities to disseminate information through communications networks could all affect power bases and, in turn, put pressures on the formal organizational structure.

Cultural issues relate to the customs, values and traditions of an organization and to how these are interpreted and acted upon by individuals or groups in concert with racial, national, family or personal makeup [Ref. 23]. Culture is obviously a manifestation of subjective elements, but belongs both in formal and informal sides of organization. For this study, power and culture may be seen as complementary aspects of the place of individuals in organizations, affecting:

- group and individual relationships;
- the perceived value of one's work;
- status and perceptions of one's movement up the corporate ladder, and
- perceptions of job security.

In summary, it appears that any consideration of the influence of EUC on organizational structure should include consideration of political and cultural elements as well as technical ones.

2. Information processing

Following the line taken by Forrester [Ref. 24], decision making in organizations is response to changing conditions, involving review of options, revision of plans and formulation of new actions for continuation of the task. Decisions require information, which flows to decision makers from various parts of the organization and from the environment in which the organization operates. The results of decisions are communicated in the reverse direction to promote action throughout the organization. Therefore communication of information from one place in the organization to another can be taken as a critical factor in the achievement of an organization's goals, and organizational structure should aim to facilitate decision making. Without information, there is no basis for decision making. As Drucker has said [Ref. 25]: "Communications and information are totally different, but information presupposes functioning communications."

In the present environment of EUC, where there is considerable potential for users to create their own machine-based information paths, the power and difficulties of information processing are readily apparent. As an early warning of the danger of disregarding this, Daniel [Ref. 26] wrote in 1961:

> Management often loses sight of the seemingly obvious and simple relationship between organizational structure and information needs. Companies very seldom follow up on reorganizations with penetrating reappraisals of their information systems, and managers given new responsibilities and decision-making authority often do not receive all the information they require.

Whether today's managers recognize the importance of information processing to organizational performance is therefore a aspect of some significance in this thesis, as it establishes the weight given to this aspect in both information systems and organizational design, and in day-to-day decision making.

Information processing combines collection, modification and distribution of data, and therefore involves elements of organization, work by people, interaction with machines and communications technology, according to Robey [Ref. 27:p. 5Ø3-5Ø4]. He goes on to address efficiency of information processing as being directly affected by flow of information and by whether its passage is direct or delayed. The interaction of the three elements mentioned above appears particularly significant in modern organizations that depend on timely information to maintain their competitive commercial advantage, and therefore how information flows through an organization is important.

a. Velocity - a function of speed and direction.

Regarding the two extremes of mechanistic and organic organizations, the velocity (a function of both speed and direction) of information flow through an organization suggests that control of information is an important issue for managers. Organization structure is both an attempt to control information flow formally and to accommodate informal flows. For example, in mechanistic hierarchies information moves according to predetermined patterns from level to level and from one area to another within a level; velocity is predictable through the processes applied by the organization. More organic groups reflect informality of information flow; speed and direction (or, more precisely, the path) of information flow change to suit prevailing circumstances, and thus these groups have a less rigid structure.

Taking the commercial situation, it is likely that a corporation operating in a very competitive, rapidly changing environment may be faced with the need to adapt its decision-making abilities, communication speed and flow paths to adapt to the uncertainties of changing business conditions. The range of structures appropriate to organizations in this environment would be different to others operating in a more static and predictable situation, where the conditions of decision making are less demanding.

3. Differentiation

Grouping is an important aspect of any discussion of organizational structure, because it involves issues of division of labor, through vertical and horizontal differentiation, to accommodate the complexity of the organization's tasks and their required coordination. According to Kast and Rosenzweig [Ref. 17:pp. 214-216], structural differentiation means:

- creation of vertical levels - a hierarchy - to allow for the application of authority and decision making and to provide defined spans of control;
- formation of departments - division of the organization into horizontal groups by functional, product, territory or customer group.

Vertical differentiation in modern organizations has tended towards four principal layers:

- top layer: the board of directors;
- upper middle layer: the managers;
- lower middle layer: the supervisors;
- low layer: those who are supervised.

Within these layers exist several further levels. It is not unusual for organizations to have perhaps 20 levels covering the four principal layers. These levels provide for rank, status, and visibility of career progression. They may be formal, as in the military where rank is visible, but often the levels are not so clearly defined. This situation leaves the way open for power and

cultural factors to predominate. The United States Navy is a clear example of visible divisions. There are 17 defined uniformed ranks. The Navy's organizational structure may provide a level for each rank, although some organizations may not include all ranks (e.g., a ship commanded by a Captain might contain 13 ranks in seven or eight hierarchical levels). Further, some organizations combine ranks within a given layer (e.g., 3rd and 2nd class Petty Officers may be junior supervisors, but are often considered in the lowest layer of 'those who are supervised').

Galbraith's work on information flow to overcome uncertainty in organizations [Ref. 28:pp. 8-20] is an important extension of differentiation. His interpretation of the bureaucratic model shows how, with little uncertainty, organizations tend to remain structurally flat (i.e. few vertical levels), with horizontal differentiation being the means of dividing labor among known tasks. As uncertainty increases, there is a greater need for information processing. Vertical layers of organization are added to control the communication of increasing amounts of information. This layering improves information processing by reducing the volume of information to be considered in any layer, but increases control and coordination because of increased organizational complexity. Therefore, multi-layered organizations are often good at making decisions, but are often inefficient in executing them. When

uncertainty increases to the extent that the hierarchy becomes overloaded , Galbraith [Ref. 28:pp. 14-19] proposes two goals for organizational adjustment - reducing the need for information processing, and increasing the capacity to process information.

Approaches have been simply to reduce output in the classical mechanistic hierarchy and to create excess ('slack') resources, or to increase the fencing of roles in order to reduce demands on the whole organization. Alternatively, improving information flow through integrating mechanisms can increase the organization's ability to process information. Integration through matrix structures has proven valuable in increasing information flow under high uncertainty as have simpler integrating mechanisms such as committees. In each case, differentiated groups were brought closer by improved communications. Generally, the groups were not removed, just made to operate more effectively together.

Robey has stated [Ref. 27:p. 408] that information technology can be used as an alternative to the integrating approaches of Galbraith. Robey discusses studies that: "show unequivocally that computers support greater horizontal differentiation." Computers therefore appear to support organizational structures with wide spans of control. In the context of both information flow and vertical structuring, Robey further suggested that, by using

computers to increase the capacity of vertical channels for processing information, more exceptions can be passed to management at successive levels, without overloading the hierarchy.

4. Communications networks

A summary of the importance of organizational communications is provided by Ivancevich and Matteson [Ref. 15:p. 631]:

> Communicating, like the process of decision-making... pervades everything that all organization members - particularly managers - do. The managerial functions of planning, organizing, leading and controlling all involve communicative activity. In fact, communication is an absolutely essential element in all organizational processes.

The velocity of information flow mentioned earlier is obviously related to communications processes. Information speed is a function of interpersonal communication, that is, the interactions between individuals and groups in an organization. The other element of velocity - direction - depends on how the organization's structural design accommodates movement of information vertically, horizontally and also diagonally between differentiated hierarchical layers and departmental groups.

Communication may be via formal organizational paths or by informal contacts between individuals and groups. Organizational 'grapevines', though by nature informal communications networks, are important components of corporate information flow. It is interesting to recognize

that power and culture are not always visibly represented in an organization's formal structure. Informal networks exist in all organizations, and are affected by power and cultural factors. In some situations the informal has been found to have more influence in the progress of the organization than the formal.

5. Synopsis

In this section, the theory of organizational structure has been discussed in general terms, and in terms of the structural variables of information processing, differentiation and communications networks.

D. REPORTED IMPACTS OF EUC ON STRUCTURE

Research over the past two decades shows a series of trends in the impact of information technology in general, and in EUC in particular, on organizational structure.

1. The view from the 1960s

At a symposium on the impact of information technology on organizations conducted by Industrial Relations Counselors in 1964, expert opinions were presented on:

- a trend away from centralized bureaucracy toward de-centralized authority and profit center accounting (Forrester, [Ref. 29:pp. 63-67]);
- declining roles of supervisors and middle managers; layers of supervision no longer needed for supervision and control; greater spans of control for a reduced force of managers and supervisors (Beaumont, [Ref. 29: p.12]);

- an example, in 1964, where introduction of a computer resulted in removal on average of two levels of jobs (filing and other routine clerical tasks such as basic manipulation of data) (Williams, [Ref. 29:pp. 17-30]);

- organizational structure would flatten, accompanied by a re-combination of former position parts into new bundles of responsibility, i.e. a whole layer of management may not be removed, the computer having taken over the tasks of some positions the rationalization process producing some new ones (Whistler, [Ref. 29:pp. 47-60]).

These opinions appear typical of the first era of corporate computing suggested by Cash et al [Ref. 6:p. 9], when mainframe-based information technology could be seen only as a productivity tool. Rather than supporting decentralization in the 1960s and 70s, information technology became focused on output at the transaction level, and opportunities for increasing economies of scale dictated that management information systems be centralized.

2. The 1980s view

The contemporary view of end-user computing is more complex than that of the 1960s. The early age of data processing addressed essentially a single technology, that of centralized, batch processing mainframe machines operating under the close control of professional information systems staff. Today, there are several layers of computing to consider, each with a different degree of maturity. Wilmott [Ref. 30] states: "each new level of technology is serving a wider audience of potential users". The range of computing tools available to an increasing population of computer-literate end-users, when applied to

corporate tasks, has caused significant changes to organizational structure, and more change is yet to come.

In a work giving examples covering the whole spectrum of structural changes caused by new information technology and EUC, Boddy and Buchanan [Ref. 31] identified several areas that will serve as predictors of impacts in today's research.

First, some of the consequences of EUC on people in organizations were discussed:

- large elements of routine, repetitive clerical activities have been removed;

- staff at all levels were provided with more information more quickly;

- providing the data was accepted as credible, staff were able to make better quality decisions by having more data available to them and by being able to sort the data into meaningful information;

- issues of power and ownership of information became visible as systems became more capable of integration. Resistance to change and reticence to give up previous perceived organizational positions also became issues.

Boddy and Buchanan then discussed a range of structural changes catalyzed by EUC:

- Substitution of old functions. In another case, several manual, paper-based clerical tasks were replaced by integrated computer terminal operations which reduced the significance of the previous function. Size of the function was reduced so that it no longer warranted departmental status [Ref. 31:p. 141];

- New support layer. In a case involving local government, introduction of networking required more departmental system support than users were able to provide themselves. One option for meeting this new requirement included creation of an Information Center, with appropriate professional staff, in the user area, to assist with development, training and implementation of the system [Ref. 31:p. 146];

- Changes in the hierarchy. Examples were given of EUC leading to reduction in manning, in turn enabling middle management levels to be eliminated. Also discussed were changes in patterns of decision making, which led to more or less centralization, depending on whether information progressed more rapidly to the top of the organization or whether the EUC technology was used to provide more information to lower levels of management enabling them to make better informed decisions [Ref. 31:pp. 146-150];

- New interdependencies. New EUC systems making use of the technical possibilities of integration of functions into a single process, and convergence - the incorporation of several functions into one machine, have been found to create new interdependencies between departments on hierarchical levels, which in turn facilitated structural changes [Ref. 31:p. 150]. This aspect is complex, as it implies issues of relationships and coordination between departments.

A number of factors affecting managers have been also been brought out by Boddy and Buchanan as being related to the existence of EUC, including [Ref. 31:pp. 157 - 174]:

- required numbers of managers and their status;

- whether more information assists or complicates decision making;

- reduction in the population of management activities;

- managers' resistance to change;

All of these factors have been complicated by the growth of specific managerial tools such as decision support and expert systems, that make clear answers to any of the

above issues difficult at best. Boddy and Buchanan discuss at length the influences of these aspects on management and organizational change, reflecting on the small population of research in this area, and give many points to ponder without themselves coming to definitive conclusions.

3. Summary

The work of Boddy and Buchanan in the area of EUC may be integrated with the results of earlier information technology and organizational research. Together, the researches show a range of impacts of information technology in general, and EUC in some particular cases, on organizational structure. These impacts are summarized in Table 2, and listed by each of the structural variables introduced during this literature review. The direct research of this thesis will effectively seek to confirm, deny or expand these views.

TABLE 2

IMPACTS OF INFORMATION TECHNOLOGY ON STRUCTURE

Variable	Impact
Information Processing	. New information paths requiring re-alignment of structure. [Ref. 26] . Reduced information overload. [Ref. 27] . Improved information flow. [Ref. 31]
Differentiation	. Decentralization of information systems affect power bases and hence structural relationships. [Ref. 22] . Wider spans of control. [Ref. 27] . Removal of clerical activities. [Ref. 31] . New support layer. [Ref. 31] . New interdependencies facilitating structural change. [Ref. 31]
Communications Networks	. Communications networks can affect both formal and informal structure. [Ref. 16]

III. THE RESEARCH METHODOLOGY

A. THE CONTRIBUTION OF THE LITERATURE REVIEW

This chapter provides the link between the results of the literature review in Chapter II, and the direct research to come. The background of EUC and organizational structure theory was established in Chapter II. Also established was a list, indicative if not exhaustive, of the organizational impacts, seen by prior researchers, that might be observed in the course of this study.

Review of the literature confirmed that influences of EUC on organizational structure have been noted in the past. While discussion in Chapter II qualified the structural variables of information processing, differentiation and communications networks in terms of earlier work, it was noted that end-user information technology is assimilated into different organizations at different rates, and that a single set of criteria for discerning EUC impacts on the structures of these organizations would not apply to every organization to be studied. These outcomes provided the basis for selection of the direct research sample.

B. RESEARCH METHODOLOGY

The case study methodology has been selected for this thesis. This methodology lends itself to exploratory

research of the kind that is being conducted here. It can be expected to expose a range of effects, to provide initial answers to the research questions and to highlight areas where more detailed research may be justified.

1. <u>Limitations of the research methodology</u>

There are several limitations of the methodology followed in this thesis that deserve mention here:

- The case study approach limits the researcher's control over the conditions of his investigation. This approach is also not empirical in nature, i.e., it is often not possible for the researcher to discern whether he is addressing an element of a discussion in its most basic form or whether the element is itself a construct of other aspects.

- The anecdotal nature of the evidence suggests that subjectivity may be present in this study. People interviewed provided responses based on their varying perceptions of the questions being asked, and their responses may have contained opinion and other subjective elements that were not able to be detected by the researcher.

- Time available for this thesis limited the size of the sample to three organizations. The range of impacts noted in this sample may be less than the range that might become apparent from a larger-sized sample.

- All the organizations studied are large. This was a deliberate aspect of sample selection, as described below, and it is recognized that the effects of EUC on the structure of medium-sized and small organizations could not be appreciated in this study.

While these limitations limit the degree of generalization allowed to the conclusions of this thesis, it is considered that this research methodology has been successful in highlighting specific impacts which can provide a range of

hypotheses for others to study under more controlled conditions.

C. SELECTION OF THE DIRECT RESEARCH SAMPLE

The criteria for selection of a sample of contemporary administration organizations for this study were:

- the organizations should be large and therefore relatively stable, and their size should allow a wide range of EUC impacts to be observed;

- they should have experience with end-user computing over at least the past decade;

- they should have sufficient capital to be able to procure the latest tools of end-user computing technology. While individual EUC tools such as microprocessors are relatively inexpensive (and this has been a major factor in EUC growth), the sum of expenditure across a whole organization could be very high (e.g. Department of Defence expenditure of $661 million on microcomputers over the past two years [Ref. 8]). Therefore, organizations should not be selected if their ability to support EUC is financially constrained.

The organizations selected for the sample were:

- a large computer manufacturing corporation which agreed to participate in the study on the basis of anonymity. (This organization is described as CMC throughout this thesis);

- The Aetna Life and Casualty Company (Aetna), and

- Stanford University.

Each of these organizations is a corporate entity of large size with a considerable history of end-user computing which, because of their respective orientations, can be expected to be employed in different ways. There is no lack of capital in these organizations to back up their effective use of end-user information technologies.

In keeping with the high-level view of this thesis, discussions were held with senior and middle-ranking corporate officers, who have significant knowledge of their EUC environment and who have the responsibility either to develop or to contribute significantly to decisions for structural change to their organization in response to EUC catalysts. The personnel interviewed represented a balance between organizational and information systems management experience, and in all cases, the interviewees had experience in both areas. Details of participants and their interviews are given in Table 3 on the next page. This table is a principal reference point for the direct research in Chapter IV.

TABLE 3

PARTICIPANTS IN THE STUDY AND THEIR INTERVIEWS

Interviewee ID	Date	Organizational Title	Duration
CMC 1	12/12/87	Director of Organization & Planning (DOP)	40 mins.
CMC 2	12/18/87	Assistant to the DOP	1 hour
CMC 3	12/18/87*	DOP	2 hours
CMC 4	01/13/88	DOP	20 mins.
CMC 5	04/12/88	Assistant to the DOP	30 mins.
Aetna 1	12/12/87	Assistant to the Vice President, Corporate Administration (VP CA)	20 mins.
Aetna 2	12/22/87	VP CA	2 hours
Aetna 3	12/22/87*	Vice President, Information Systems (VP IS)	2 hours
Aetna 4	01/14/88	Assistant to the VP CA	40 mins.
Aetna 5	02/09/88	VP IS	30 mins.
Aetna 6	04/20/88	Assistant to the VP CA	25 mins.
Stanford 1	01/29/88	Associate Director, Information Technology Services (AD ITS)	1 hour
Stanford 2	02/19/88*	AD ITS	2 hours
Stanford 3	02/26/88	AD ITS	2 hours
Stanford 4	02/26/88*	Associate Director, Networks & Communications (AD N&C)	1 hour
Stanford 6	03/04/88	Manager N&C	2 hours

All of the personnel interviewed were very knowledgeable and professional, and did their best to assist this study. Following the interviews at CMC, Aetna and Stanford, with dates marked with an asterisk, informal discussion also took place with end-users at lower levels of organization, to gain further background of the situations that had been discussed more formally.

Restrictions in available time and funds for travel and the location of CMC and Aetna corporate offices in New York state and Connecticut respectively, necessitated that physical contact occur in a compressed time period. These organizations were contacted in November 1987 and preliminary discussions held by telephone. Interviews were carried out over two days in December 1987, with follow-up correspondence and telephone discussions during the period through April 1988. In the case of Stanford, locality was more proximate, and a series of visits was achieved over the period January - March 1988.

D. THE INTERVIEW APPROACH

Interviews began with general discussion of corporate views toward information technology and EUC in particular. The aim of this open-ended approach was to allow key issues to become apparent as early as possible. This informal start was followed up by a semi-structured question and

answer period, during which the following specific aspects were covered:

- the strategic policy of the organization regarding EUC, and the status of EUC in the organization;
- an assessment of the degree of application of computing tools by the end-users in each organization;
- movements in organizational structure over the past five years, and whether EUC instigated or facilitated these changes, and
- the impacts of EUC on the structural variables of information processing, differentiation and communications networks, introduced in Chapter II.

Each of these aspects allowed incremental development of answers to the research questions, while providing for variations in responses from each organization. In the CMC and Aetna cases, the face-to-face interviews were followed by telephone interviews and follow-up discussions to clarify points. In the Stanford case, both interviews and follow-up were achieved on site.

The interviews sought to:

- test agreement with, or variance from, previous research results;
- identify impacts of EUC on organizational structure that may have not previously been reported, and
- explain the variances discovered.

This study has aimed at providing a first step in the investigation of the impacts of EUC on organizational structure. Use of semi-structured interviews served to bring out considerable high-level information about both EUC and structure in each organization. While there are

limitations in this approach, as has been discussed, the case methodology and interview approach has succeeded in exposing impacts of EUC on the structure of the sample organization. These impacts are now discussed in Chapter IV.

IV. DIRECT RESEARCH IN THE SAMPLE ORGANIZATIONS

A. INTRODUCTION

As stated in Chapter III, this chapter contains the results and interpretations of direct research in three large, complex organizations that have a considerable history of EUC:

- a large computer manufacturing company, referred to here as CMC. (This corporation agreed to participate in the study on the basis of anonymity);
- The Aetna Life and Casualty Company (Aetna), and
- Stanford University.

These organizations provide a range of possibilities for view of the impacts of EUC on structure. CMC is in high technology manufacturing and marketing, and aims to integrate information technology into its corporate political and cultural environment. As an insurer, Aetna is more involved in the gathering and marketing of information itself than is CMC (which is more oriented to physical products). Aetna places more emphasis on information processing in its own right and is committed to the use of information technology to achieve change in the corporation. Administratively, Stanford is no less a corporate entity than the other two, although it is less directly involved in marketing discrete products in its day to day operations. Stanford's systems are mature but, like Aetna, its EUC

environment is changing in form, with present emphasis being on communications networks.

The organizations all have a long history of in-house administrative computing, and have progressed to decentralized end-user environments - e.g., timesharing, departmental systems and microcomputers - during the past 15 years.

Each of these organizations approaches the exploitation of information through EUC in different ways to meet differing corporate goals. It is these differences that will be valuable in judging the significance of those impacts of EUC on structure that have been noted during this study.

In addition to the normal publications in the List of References, a set of research interview references is used in this chapter (e.g. [Aetna: Ref. 2], which refers to the second Aetna interview listed in Table 3, Chapter II). These interview references are the primary source of the evidence for this thesis.

B. A LARGE COMPUTER MANUFACTURING CORPORATION (CMC)

CMC is a large manufacturer of computing equipment and software. For this thesis, a high-level view of the whole organization was taken from the perspective of the corporate headquarters. Through this view, trends in EUC and structure could be seen on the basis of a single

organization rather than from the perspective of its component divisions or departments.

1. The background of EUC at CMC

Computing end-users at CMC have access to a wide range of mainframe, midrange and microcomputers. Timesharing terminals or microcomputer workstations are on the desks of almost all executive and administrative assistants throughout the headquarters, and this was stated to be characteristic of the situation throughout the administrative echelons of the corporation. As an example of the level of connectivity available to end-users, all of the terminals and networked machines are able to pass messages to each other in the headquarters and, indeed to any other terminal or network machine in the corporation. Other software applications available to administrative and management personnel include word processing, spreadsheets, query and update access to various databases. Some terminals were able to present graphics as well as text. EUC is significant in this corporation.

CMC believes that, across the corporation as a whole, the facilities available to end-users have reached maturity, and that computing hardware and software have become part of the office background to end-users [CMC: Ref. 1]. The CMC view that information technology supports organization, and more often facilitates than instigates

organizational change, will be repeated throughout this case study.

In terms of the Munro and Alavi models [Ref. 12, 13] noted in Chapter II, CMC has followed strategic policies aiming at controlled growth of end-user computing. That is, CMC has chosen to allow EUC to grow to suit the information processing needs of end-users but, at the same time, to control the environment in which the growth occurs. The research by Munro et al [Ref. 12] indicates that firms that have reached maturity of EUC achieve a balance between growth and control, and this appears to be the case with CMC. Structurally, EUC is centrally planned and monitored, although the responsibility for meeting central policies and standards rests with individual operating divisions. Integration and efficiency were reported as the principal objectives of EUC, with information technology expected to contribute measurably to individual efficiency [CMC: Ref. 3].

CMC appears to have followed the three eras of computing suggested by Cash et al [Ref. 6:p. 9]. In particular, the backlash of user disenchantment was felt during the 1970s and early 1980s with the inability of central information systems (IS) facilities to develop and amend departmental systems at the rate users desired [CMC: Ref. 2]. The relationship between users and IS management was repaired by a deliberate corporate policy to establish

micro-to-mainframe links as soon as possible after the introduction of the PC in the early 1980s [CMC: Ref. 3]. CMC's inter-computer communications architecture and standard office automation software environments have improved departmental, divisional and international networking between individuals throughout the corporation, upon which CMC heavily depends today.

EUC has helped decentralize some of the classical 'centrist' structure of information systems management as many of the previously central tasks of low-level information systems development and maintenance have been transferred to departmental level. While this decentralization has been achieved for relatively simple tasks, a considerable amount of administrative systems development and life-cycle maintenance still rests with central IS personnel located at divisional level or at special corporate systems support centers, rather than with end-users [CMC: Ref. 3]. CMC prefers end-users to work corporation-wide environments (such as their office automation systems) rather than with narrower divisional or departmental utilities because this reduces maintenance overhead.

The comment was made [CMC: Ref. 3] that, in the past, corporate information systems (IS) managers did feel threatened by the rapid growth of EUC but have now adapted to it. Having lost some of its power in the late

1970s/early 1980s, mainly through the defection of mainframe users to departmental and standalone microcomputer systems, central IS management is accepted as again having the expert power position. This change in position has been catalyzed by increased networking of computing resources throughout the corporation. End-users have come to accept that information processing productivity rests not with standalone or localized applications, but with connectivity to machines and databases outside their immediate environment via common application packages, provided by central IS management. Having gained acceptance for common systems and having achieved commonality for at least the newer systems, central IS maintenance overhead for EUC has stabilized. IS staff appear better motivated to responding to customer desires. End-users at the CMC corporate headquarters spoke of "almost daily questionnaires" appearing at their terminals via electronic mail, soliciting responses to central IS management or departmental Information Centers (IC) on problems with operations of a given system or ideas for improvements [CMC: Ref. 3]. While users appear to accept the management position of central IS, there still remains a balancing force in the large population of increasingly computer-literate end-users who, individually or in work groups, are quick to express dissatisfaction with systems that perform inadequately.

CMC end-users access a wide range of hardware and software tools to access databases, manipulate data, formulate reports and exchange information. The majority of information systems accessed by end-users are mainframe (at divisional levels) or minicomputer based (at departmental levels). Local area networks are being implemented more to enhance the power of larger systems through connectivity, rather than to replace them. It is interesting to note that CMC does not support the present trend to intelligent workstations above the level of personal microcomputers. This follows a corporate IS strategy, reflected also in the CMC product line, to link low-level systems, as terminals, upward to departmental midrange and mainframe machines, rather than encourage the downward and lateral distribution of databases that is a factor in workstation usage, and which brings problems of maintaining information coherence [CMC: Ref. 4].

From all of this discussion, the status of EUC at CMC appears one of corporate-wide maturity and acceptance. End-users have effective environments with which to work, and they appear to have the power to obtain support from central IS managers as needed. EUC is widespread and growth meets needs articulated by end-users themselves.

2. <u>Information Processing</u>

While users have wide access to databases, it was emphasized that, to reduce information overload at higher

organizational levels, there is a policy to maintain all but financial databases within divisional boundaries, and to thereby limit the free access of users generally to data within their own division. This alignment of CMC organizational/information structures and end-user access is a deliberate action of combined organization and IS design [CMC: Ref. 2], and relates to equally deliberate 'channels' of information processing described in the Aetna case to follow. A corporate officer requiring an ad-hoc report about the performance of a particular division would contact the division by electronic message or phone to request the desired information. This is not to say that data does not flow electronically between divisions or to corporate level. Rather, CMC emphasizes that information is best treated as 'owned' by identifiable groups. Such integration of end-user databases and organizational structure reflects the corporate view that divisions act better when given autonomy, and ownership of data is one way to reinforce this.

Co-operation between organizational design and end-user information flow, as evidenced by the above example, indicates construction of 'channels' in organizational structure. This structural impact was instigated by the existence of EUC technology which, unless constrained, could have, in the CMC case, resulted in information overload in the corporation. A sectored

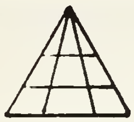
triangle might be used to represent this deliberate channeling of information, and is shown in Figure 3. The triangle is introduced here as the standard symbol of hierarchical organization to be uses throughout this thesis and, in the figure below, a series of lines are drawn from the base of the triangle to the apex to represent vertical information flow. These lines intersect with horizontal lines which portray lateral information flow. Both sets of lines are intended to emphasize controlled flow of information along predetermined paths within the organization to achieve management goals. In this case CMC channeled information to prevent its uncontrolled movement as a result of EUC.

Such pictorial representations of the impacts of EUC on organizational structure are not intended to imply any particular scale of change, but rather the nature of one type of EUC impact as compared with another.

In the case of CMC information channels, EUC instigates structural change. The power of end-user technology to transfer and process information called for controls to prevent information overload. Thus EUC mandated the structural controls in this example.

Figure 3

Information Flow Structural Impact of EUC



the sectored triangle, showing channels of information flow, designed into the organizational structure with EUC.

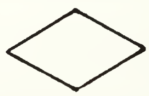
Widening of management spans of control, without prejudicing individual manager effectiveness, reflects a further aspect of information flow noted during this study. CMC uses independent teams to carry out specific, short-life tasks. With up to eight independent teams reporting to a single manager, spans of managerial control have increased significantly from older departmental norms, which tended to have three or four section heads reporting to one point. The efficiency of EUC, particularly to give managers access to team databases for project management and finance, has reduced the upward flow of information. The manager can now look downward at will, through EUC access, increasing his ability to discern trends in team progress and to evaluate positive or negative variance to plan.

This example of the information flow structural impact of EUC, which has been described in Chapter II, is represented again by the diamond shape as in Figure 4, which depicts the wider spans of control for a given middle manager and overall reduction in the number of middle managers for a given population of tasks.

The degree of increase in CMC spans of managerial control appears directly related to the increase in effectiveness of information processing for a given work group. Therefore, in this example, EUC is facilitating structural change.

Figure 4

Information Flow Structural Impact of EUC



the diamond, recognizing increased spans of control and consequent reduction in management numbers.

4. <u>Differentiation</u>

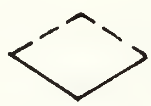
CMC undertook major corporate re-structure in 1956, with the change, as described by one executive, "from the owner as a one-man band, to a corporate, responsibility based structure" [CMC: Ref. 3]. In the 1960s, new divisions were established to cater for changed markets and, in 1975, functionally-oriented divisions became grouped by market application. Divisions were granted significantly greater autonomy in 1987/88, to encourage more individual activity in an increasingly competitive commercial environment.
A more autonomous divisional structure aims to help focus specialization; it retains a concentration of corporate authority and a hierarchy of decision-making power, while minimizing the size of staff elements in relation to the line management force.

CMC considers that EUC technology has influenced changes in the structure of administrative groups within the corporation, but often only at relatively low levels [CMC: Ref. 1]. For example, with the increase in productivity gained from EUC tools such as word processing, electronic messaging and appointment scheduling, one administrative assistant is now able to serve six senior executives in the corporate headquarters. Ten years ago, the same position served only two people [CMC: Ref. 5]. An expert view [CMC: Ref. 3] was that groups within the organization are not subjected to re-design in anticipation of given changes in information technology, unless the impacts of the technology are well known and can be fully anticipated (and this has rarely been the case). In the CMC experience, personnel savings have tended to become apparent only after some experience of a new system, not before its installation. Employees displaced by the new environment have been re-trained for other duties or transferred to vacant positions with similar duties in another department. (It should be noted that, until very recently, CMC corporate policy was never to force the retirement of a permanent employee, so the corporation historically did not set out to use information technology simply as a means of reducing staffing.) In this general sense, EUC has facilitated rather than instigated structural change at CMC.

From the above example, EUC has been seen to contribute to reduction in staffing through the increased productivity that computing tools bring to end-users. Thus one employee was able to support more executives with EUC than without. This example of a differentiation impact of EUC might be represented by the lower half of a diamond shape as in Figure 5.

Figure 5

Differentiation Structural Impact of EUC



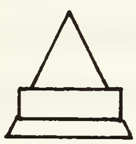
the bottom half of the diamond, recognizing increased spans of responsiveness.

CMC was a principal pioneer of departmental Information Centers as a means of improving the support of computing end-users. Following the introduction of the PC to general administrative use, it was recognized that having significant localized computing resources in the hands of computing non-professionals would hamper rather than improve operating efficiency unless end-users were adequately trained and operationally supported. This is a case where the existence of EUC instigated structural change, the addition of a support layer to ensure that EUC itself had the best chance to provide the required return on corporate computing investment.

This example of a vertical differentiation structural impact of EUC might be represented by the stepped pyramidal shape in Figure 6. This shape starts with the equilibrium organizational structure, the triangle. Need for EUC support necessitates insertion of the IC as a new organizational element - represented by a rectangle. The sides of the rectangle overlap the triangle slightly, depicting a situation where the new organizational layer creates a structural form which is not the same as the previous one.

Figure 6

Differentiation Structural Impact of EUC



the stepped pyramid, recognizing insertion of a new layer of organization to support EUC.

4. <u>Communications networks</u>

According to CMC staff [CMC: Ref. 2,3], the implementation of their standard office automation environment throughout the corporation and acceptance of electronic messaging as a legitimate communications medium in the mid-198Øs significantly expanded the influence of computing end-users as individuals and as representatives of particular groups. End-users in differing functional groups, in different parts of the world, access central processors at their own and other departmental and

divisional level in order to transact electronic messaging and to exchange data files that have been requested.

CMC has maintained a policy of getting geographically disparate groups together, so that "people can get to know each other's faces" [CMC: Ref. 3]. Regular scheduled conferences gather together peer groups from throughout the corporation to meet, discuss problems and solutions of mutual interest, and to simply get to know each other as individuals in an organization with many thousands of employees. CMC's corporate view is that lateral relations among peers are enhanced by personal acquaintance [CMC: Ref. 4]. The belief at high level in CMC is that people who know each other personally can work better together as end-users in the electronic environment, even though geographically separated, often by continents rather than cities.

By connecting disparate groups throughout this large and dispersed corporation by end-user tools such as electronic messaging, CMC has created the means to strengthen the informal interpersonal communications networks throughout the corporation. The aim has been to create greater integration in the style of Galbraith [Ref. 28] as discussed in Chapter II. Given that information processing requirements increase in a growth-oriented commercial environment, i.e. information processing must increase rather than decrease - organizations must

communicate more rather than less in order to integrate better their activities, then increases in the productivity of information exchange are necessary. Electronic messaging is accepted as an end-user environment because of the use of computer communications networks and the processors that link them. The links are formal but the communication on these networks is often quite informal, i.e. without regard to organizational boundaries and hierarchies. By emphasizing an informal organizational environment, therefore, CMC seeks to make the overall performance of the formal (i.e. visible) organization more effective. The comment was made that CMC "cannot afford now <u>not</u> to have this kind of integration." [CMC: Ref. 5].

In CMC the corporate structure is taken seriously. The networks and teams of people and machines are enhanced by regular rotation of managers through a variety of positions to groom them for higher responsibilities and to maintain their interest in a career. Care is taken to minimize the impact of change on personal aspirations, themselves considered important elements of personal effectiveness. The point was made [CMC: Ref. 1] that, even though new information technology tools might suggest structural change, the corporation might reject or postpone the opportunity because of its potentially adverse impact on existing organizational networks.

Notwithstanding this comment, CMC uses information technology and the availability of links to a large population of end-users to maintain communication of corporate, group, divisional and departmental goals. The CMC view is that "without goals and common understanding of them, communication becomes random" [CMC: Ref. 5]. Effective communication networks also are considered to improve feedback of organizational performance to goals.

Information networks have played a part in all the structural impacts of EUC noted above. Therefore information networks, in the CMC case, appear to be a general rather than a specific influence on structural change. This is related to the concept of 'neutrality' of computer communications networks discussed later in the Stanford case.

5. <u>Summary</u>

The study of CMC has given an example of an apparently stable EUC environment. The findings of this case are summarized in Table 4 and later in other tables in Chapter IV, and these findings are interpreted in Chapter V.

TABLE 4

ENVIRONMENT OF EUC AND ITS STRUCTURAL IMPACTS AT CMC

Strategic policy	: EUC is an integral part of the CMC operating environment.	
	Controlled growth to improve spans of control and to meet user needs.	
EUC status	: Widespread, modern, integrated into the operating environment.	
	End-users appear to possess some organizational power.	
Impacts Noted		
Information Processing	: Channels of information flow, designed into the organizational structure with EUC (Figure 3).	[I]
	Increased spans of control. (Figure 4).	[F]
Differentiation	: Increased spans of responsiveness (Figure 5).	[F]
	New layers of EUC support.	[I]
Communications Networks	: Electronic networks enhance the informal structure but, in turn, make the formal structure more effective.	[F]

Legend:

EUC instigates [I] or facilitates [F] structural change.

C. THE AETNA LIFE AND CASUALTY COMPANY

The Aetna Life and Casualty Company (Aetna) is one of the nation's largest insurance corporations, with corporate earnings last year of $1 billion from sales of $12 billion. Corporate headquarters are in Hartford, Connecticut. The discussions for this study were held with Aetna officers as detailed in Table 3 in Chapter III. They provided anecdotal evidence of a strong emphasis on information processing as a primary element in corporate strategy, and on end-user computing as a major tool in its implementation.

1. The background of EUC at Aetna

Aetna takes the same general view (also established in the definitions presented in Chapter II), that EUC is considered an environment, through which users at all levels of the organization and even users beyond Aetna itself may apply various computing tools for their own individual business purposes [Aetna: Ref. 2]. This view is not constrained to organizational position, type of hardware or software, skill level of user, or application being used.

The wide range of definitions of EUC given in Chapter II are applicable to the Aetna case. Throughout the corporation, EUC tools are made easily available in the belief that wherever they have a good chance to improve individual information productivity, they should be used. The EUC environment of Aetna is stronger than for CMC, and in terms of the Munro et al model [Ref. 12], discussed in

Chapter II, EUC at Aetna appears to be going through a phase of acceleration, albeit under management control. The nature of this growth will be examined in more detail during this case.

In particular, Aetna seeks to make 'indirect' end-users - those who use computers through other people [Ref. 5:pp. 288-289] - into 'direct' end-users, those who actually use terminals themselves. Both within and beyond Aetna, a policy is being implemented to proliferate terminals with access to Aetna databases. Aetna seeks to reduce corporate administrative costs through information technology and, in particular, EUC is seen as the key to greater future productivity and hence profitability.

The company has integrated information into all levels of corporate strategic planning. Aetna's Vice President of Corporate Administration, Irwin J. Sitkin, was quoted in CIO Monthly as saying:

> The name of our game is getting the right information to the right person at the right time to make the right decision, because in that way we will win in the market place. [Ref. 32]

Mr. Sitkin places himself as the Chief Information Officer of his organization, specifically responsible to the Aetna Board for the successful implementation of his strategy of information.

2. Information processing

A key component of Aetna EUC strategy is improvement of corporate information processing. Implementation of this strategy is most commonly achieved by replacing manual interface points - data entry and distribution, low-level client and field representative liaison and entry-point accounting - by direct links between remote terminals and central mainframe processors that serve all corporate operations. Aetna's view is that information technology is now capable enough and relatively inexpensive enough to be applied on a large scale, allowing substitution of more expensive administrative people by machines and freeing these personnel for duties not able to be mechanized on automated 'channels'.

After a significant rationalization of machines and database structures, all data is now centralized on three large mainframes, to which most levels of corporate activity have access. In the words of Aetna's Vice President of Information Systems:

> Instead of three machines, we run them like many, well-controlled small machines, very responsive to a wide range of end-user requirements. [Aetna: Ref. 3]

Aetna links many mini and microcomputer networks to these mainframes, and is installing increasing numbers of powerful workstations for intensive analysis tasks using distributed data. The workstations are considered very cost-effective, with multi-tasking, large local storage and

cost/performance ratio in the region of $1000 per Mips [Aetna: Ref. 3].

It appears that information processing and communications have been considered together in the evolution of Aetna's end-user systems. While control of data integrity has remained centralized, computing power - upon which users' ability to exploit data depends - has been decentralized. Diverse user groups have been linked under management policies clearly identifying end-user computing with corporate effectiveness [Aetna: Ref. 2].

To improve information in the context of 'velocity', as was discussed in Chapter II, Aetna has designed into the organization 'channels' [Aetna: Ref. 2] for specified types of information. For example, prototype microcomputer "kiosks" are being set up in public areas of a test sample of office buildings to attract people who might require information on Aetna insurance products [Aetna: Ref. 2]. As end-users, these prospective clients can use the kiosks as terminals to access Aetna computers, perform profiles of their insurance needs and gain quotations for services desired. By projecting computing technology beyond its own walls, Aetna seeks a competitive commercial advantage by placing its 'front office' in the workplace of potential clients.

The kiosk plan is an example of a combination of improved velocity of information processing and extension of

organizational structure through EUC, both of which were discussed in Chapter II. By linking the kiosk terminals direct to Aetna mainframes, both information direction and speed of transaction are known, and the overall result is expected to be higher efficiency than with the present system of query to human operators. These terminals also extend the Aetna organization beyond its normal boundaries, adding a new group of end-users. While the size of this group cannot be determined accurately, the greater the number of kiosks, the greater the potential size of this direct end-user population.

Creation of a 'logical office' through use of a remote terminal provides a decision support system which requires no manning. Thus two layers of low-level clerical support - employees and supervisors - will gradually be displaced by the kiosks, allowing previous contact employees to be re-trained for higher-level follow-up tasks. This kind of structural extension of organization is similar to the use of automatic teller machines by banks, but provides a higher level of intelligent service.

These channels, the creation of an extension to organization and the opportunities for progression to higher-level tasks, are all examples of information processing structural impacts of EUC. They are represented in Figure 7.

The use of a sectored triangle to represent channeling of information in an organization was addressed in the CMC case (Figure 3), with the CMC example being to reduce information overload throughout the corporation. In the Aetna situation, the information channels are designed to control the entrance and exit of particular data to a particular kind of end-user/client.

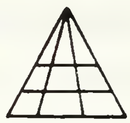
The second picture of Figure 7 represents a particular kind of interorganizational situation - connection of a formal hierarchical structure with an external, informal one. The triangle representing Aetna is placed on top of a rectangle which represents the non-hierarchical mass of kiosk users. The kiosk user rectangle must touch the bottom of the Aetna triangle as the kiosk users are, at the time of their transactions, operating as end-user extensions of the Aetna organization.

In the third picture, the height of the triangle that represents Aetna has been lessened to represent reduction in the number of vertical layers in the Aetna organization as a result of displacement of clerical personnel by the kiosk end-user situation.

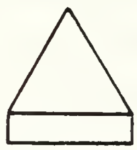
In these examples, EUC is facilitating rather than instigating organizational change. The expanded EUC environments allow alternative information channels which, in turn, allow clerical staff to be re-allocated to other tasks.

Figure 7

Information Processing Structural Impacts of EUC



the sectored triangle, showing channels of information flow, designed into the organizational structure with EUC.



the triangle on block, recognizing extension of formal organization with a further informal one, of indeterminate size.

the flat triangle, recognizing reduction in hierarchical levels through automation of manual tasks by EUC.

On a larger scale, Aetna is embarking on improvements in information processing which also include structural extension, this time an interorganizational one [Aetna: Ref. 2]. Aetna's principal sales processing is through a network of affiliated but independent agents. The company has developed a minicomputer-based, multi-user, multi-terminal system which it offers for minimal cost (support included) to agents to support their sales work and to provide automation of office and business tasks. Remote connection to Aetna mainframes gives the agent on-line and rapid access to sales support information as well as client histories from other locations. This connection also allows all agent transactions to be passed to Aetna on-line, obviating the need for several layers of general

administrative, data entry/distribution, accounting and agent liaison staff in the Aetna offices.

The system enhances the connection between Aetna and its agents, reducing their independence by increasing their reliance on an embedded end-user computing system. The agents develop enhancements to the baseline system for their own individual purposes, aided as required by Aetna IS personnel. In this way, the agent, as an interorganizational end-user, operates within the Aetna computing structure and thus becomes an extension of the Aetna organizational structure.

This joining of two organizations through EUC may be represented by two triangles, touching as in Figure 8. The different sizes of the triangles recognizes the differences in the relative sizes of Aetna and the independent agents, but it is accepted that interorganizational connections could also be between structures of equivalent size, with the triangles represented equally in that situation.

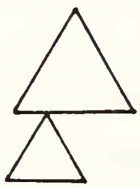
Displacement of clerical personnel by this interorganizational EUC removes two layers of personnel, and this reduction in hierarchy may be represented in the same way by the flat triangle in Figure 7. Retraining of personnel is addressed in the section on Differentiation below.

As in the previous examples in this case, EUC is facilitating rather than leading organizational change. As

was stated for the kiosk situation, EUC allows alternative information channels to be set up, presenting an opportunity for clerical staff who were previously involved with these tasks, to be allocated to other duties.

Figure 8

Information Processing Structural Impact of EUC



Stacked triangles, recognizing the linking of one formal organization to another through EUC.

Like many other corporations, Aetna issues portable microcomputers to its field representatives, with which they can operate remote terminals to their departmental systems or to the central databases, and with which they can either communicate results of their field transactions or seek information held in central files [Aetna: Ref. 5]. Again, the use of EUC to achieve a technology-based process has allowed Aetna to reduce staffs previously involved in field liaison, data entry and distribution, with a further contribution to reducing clerical layers, portrayed in Figure 7.

3. <u>Differentiation</u>

Aetna has implemented a plan to reduce corporate staffing by 30% as a result of the increased information processing efficiency of EUC systems. The plan will achieve

its reductions primarily through attrition and use of retrained staff to fill vacancies in other areas of corporate expansion [Aetna: Ref. 1].

The staff reductions are to be accompanied by changes in vertical and horizontal differentiation. The corporate objective is no greater than five vertical levels overall, and no more than five groups reporting to a single manager [Aetna: Ref. 2].

The company used to employ a large Organization Development (OD) staff but this exists now as a corporate nucleus of six people. OD professionals are appearing again at divisional level in the corporation, in recognition that any work to improve information systems must be balanced by carefully considered adjustments to the organisational situation, particularly to ensure power and cultural relationships remain stable, and to ensure that long term career progressions are not prejudiced. Aetna is conscious of the interplay of political, cultural and technical factors in the organization, much as described by Tichy [Ref. 18] and Leavitt [Ref. 20], and discussed in Chapter II. Their OD approach appears sensible in that it preserves the corporate priority on end-user information processing, while respecting the impact of quite significant organizational change on Aetna employees.

The kiosks, interorganizational minicomputers and field representative portable microcomputers represent

initiatives aimed at removing some of the lower organizational layers. Aetna is in the early stages of staff adjustments as a result of all these programs, and not more than 20% of the potentially affected clerical personnel have been displaced. The policies have a long term view, and the full effects of EUC-sponsored change in the clerical area may not be visible for three to five years [Aetna: Ref. 4].

To balance the removal of lower organizational layers, Aetna has started to make changes in the nature of administrative work. With the computing power now available to end-users, the approach is to retrain people away from simple input/output processes to higher-level data access, processing, presentation of information and its interpretation. Aetna calls people operating at this level 'information technologists' and has high hopes that, having raised these people to higher organizational levels, they will act more independently within broader guidelines than existed in the former clerical environment, and supervision requirements should be reduced. Initially 30% of all Aetna's clerical jobs will be moved to this higher employment level, and further moves are expected as the information base of the organization expands [Aetna: Ref. 6].

There is a significant load of training and user support implied in this EUC environment. Expert systems are

planned to assist the training of new end-users, and Aetna has for some time been using a range of formal user support groups including Information Centers. However, the workload of EUC management and user-level system maintenance is increasing. Therefore, the structural savings achieved through end-user technology are to some extent balanced by the need to create new support layers with personnel re-trained from other clerical tasks or deployed from central IS organizations. Much of this re-structuring is fluid, with small support teams moving to the points of present need [Aetna: Ref. 4]. These changes in organizational structure may be represented by Figure 9.

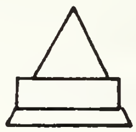
The first picture, the stepped triangle, was discussed in the preamble to Figure 6, in the CMC case. In this case the insertion of potentially more than one layer of fluid EUC support may suggest a more complicated representation. For simplicity, the team support concept of Aetna will be represented as insertion of support layer, without elaboration.

The second picture is new. Here an attempt is made to represent the effect of decentralization on structural form. The basic hierarchical triangle is changed by 'pushing in' its sides. In this way, the top of the triangle (the 'central' portion of the organization) is made thinner by reduction in its manning, and the lower portion

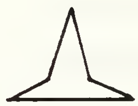
is made relatively broader by the addition of people by the decentralization action.

Figure 9

Differentiation Structural Impact of EUC



the stepped pyramid, recognizing insertion of one or more new layers of organization to support EUC.



the variable aspect triangle, representing de-centralization of support to the EUC area.

In the Aetna case, as with the decentralization example at Figure 6, EUC technology has instigated organizational change by forcing development of support, both in terms of new personnel and in terms of existing staff moved from central areas. Also, structural change was instigated by mandatory additions of support layers for the necessary management and maintenance of EUC systems.

4. Communications Networks

Having rationalized its large mainframes from 11 to three [Aetna: Ref. 5], Aetna might have been thought to have simplified its communications environment. On the contrary, the company's insistence on central databases has increased the complexity of communications to lower-level computing systems. Wide and local area networks are meshed with dial-up remote lines into a complex environment that is made

to appear as transparent to users as possible. It is through these networks that the structural extensions of Aetna, logical and physical, are achieved, and through which the company can achieve growth without increases in its own hierarchy. The communication network aspects of EUC in Aetna appear to support formal organization more directly than in the CMC case. In general, the role of communications networks in structural change, from this case, appears to be to support the effects of changes through information processing and differentiation.

5. Summary

Aetna realizes that information is "often the actual product offered to customers" [Ref. 32]. A balanced strategy of technology and people operating in modern end-user computing systems appears to be providing a sound basis for corporate profitability and growth. Change of this magnitude cannot be achieved quickly, but Aetna directing officers are working to a long-term strategy that recognizes that structural changes being achieved through EUC today are essential for tomorrow. In short, EUC appears critical to reshaping Aetna for the future.

The following Table 5 summarizes the environment of EUC at Aetna, and the structural impacts noted in the course of this study. These will be interpreted in Chapter V.

TABLE 5

ENVIRONMENT OF EUC AND ITS STRUCTURAL IMPACTS AT AETNA

Strategic policy	:	EUC is a primary element of corporate strategic policy. Accelerated growth under deliberate implementation plans.
EUC status	:	Widespread, modern, primary force for change; users changing duties.
Impacts Noted		
Information Processing	:	Designed information channels. [F] Extension of formal organization with a further informal one. [F] Reduced hierarchical levels through EUC automation of manual tasks. [F] (Figure 7). Linking of one organization to another through EUC (Figure 8). [F] Planned staff reductions through increased EUC efficiency. [F]
Differentiation	:	'Information technologists' raise clerical jobs to new level. [F] New support layers (Figure 9). [I] Decentralization of IS resources (Figure 9) [I]
Communications Networks	:	Networks support wide range of remote computing services upon which EUC strategy depends. [F]

Legend:

EUC instigates [I] or facilitates [F] structural change.

D. STANFORD UNIVERSITY

Located at Palo Alto, California, Stanford is a large and complex organization, but differing from CMC and Aetna in that it operates predominantly from a single geographical location. A population of 1,200 faculty, 14,000 undergraduate and 7,000 graduate students, and 12,000 supporting employees are gathered under a charter to educate and be educated, to perform research and to serve the public interest. The university has a strong reputation for innovation and risk-taking in research, and its single-location size, diversity of computing environments and years of computing experience, including EUC, supported its selection as a balance to the more overtly commercial entities of CMC and Aetna. In the single location environment of Stanford, issues of EUC with particular reference to centralization and de-centralization are more visible than at the multiple locations of the other corporations studied.

Interviews were held with Associate Directors of the Information Technology Services and Communications and Networking departments of the Information Resources organization at Stanford (see Table 3, Chapter III), together with informal contacts with staff and computing end-users in various schools.

1. The organizational structure of Stanford

The scope of administration includes the offices of the President and of the Provost (who is the acknowledged center of financial control), seven major schools, approximately 170 different departments (80 administrative and 90 academic), a large Medical Center and the Stanford Linear Accelerator. Departments are autonomous although they are subject to central policy direction, general operating funds control and student administration. The university funds its annual operating budget of more than $300 million, and a total budget exceeding $800 million, from a combination of income on investments, fees, general grants from alumni and other donors, and research grants, either general or directed to specific purposes. While the majority of financial management is centrally managed, individual departments obtain and control funding for some local programs [Stanford: Ref. 1].

If there is a single source of the present structure of the overall Stanford organization, it would be finance. Administration of money and student affairs ('student' implying money through tuition fees and chargeback for other services) have been centrally controlled as a matter of standard practice.

While a significant degree of administrative power rests with the Provost, the diversity of activities throughout the university causes the organization to exist

in loosely defined layers rather than as a formal hierarchy. An administrative executive described the organizational environment:

> Power is decentralized; decision processes are slow and require consensus...universal agreement among peers is difficult to come by. [Stanford: Ref. 1]

Stanford has historically separated academic from administrative functions, but organizational structures have often brought the two together as power bases shifted. Thus it is not surprising that the environment of academic and administrative computing at Stanford has also undergone pendulum-like swings between the extremes of coalition and separation, and that end-user computing has also followed organizational cycles of centralization and de-centralization.

2. <u>The environment of computing at Stanford</u>

Stanford's computing hardware resources reflect the mainframe, mini and microcomputing environments available to contemporary organisations. End-user have access to mainframe databases via timesharing terminals or increasingly via microcomputers acting as terminals in a backbone data network covering the whole university. Very few midrange computers in departmental use perform other than academic administrative tasks. At departmental level, use has been made of microcomputers as standalone word processors and financial accounting support machines, and there is considerable impetus for departments to create

local area networks leading towards single administrative system images for each department. EUC at Stanford is therefore in transition from mainframe-based to departmental administrative computing environments. While not rapid, growth of departmental systems is proceeding on three bases:

- standalone applications tailored to a single user or small group;
- departmental applications where mainframe data is enhanced at departmental level, and
- administrative procedures are being progressively reviewed to see where EUC can improve productivity.

The emphasis on central control of finances, mentioned above, has catalyzed development of central mainframe databases for finance and student administration. Originally implemented in batch mode, these systems are now functioning as timesharing environments. Thus, Stanford's mainframe administrative systems are mature, well operated and controlled. They have evolved to complex central database structures as would fit stage 5 of the Nolan technology assimilation model [Ref. 10]. Historically, administrative EUC in Stanford has meant departmental personnel accessing mainframe files for their local information. Updates to centrally controlled files have been via input offices themselves controlled centrally, as it is current policy that such files are not departmentally owned.

There is yet no trend to change the orientation of financial data processing, but de-centralization of student administration has begun, on a trial basis, in the Law School [Stanford: Ref. 2]. Users have been seeking greater ownership of data and more control of its processing at departmental level, and therefore the Law School example appears to be only the start of a longer term trend to greater end-user autonomy. Stanford's central directing Information Resources (IR) staff believe that, over the next five years, significant distribution of administrative processing will be achieved [Stanford: Ref. 2].

Overall, the environment of EUC in Stanford's administrative's areas is undergoing slightly accelerated growth and is starting to assume a more distributed outlook. The status of EUC is changing from a widespread but subservient user environment to one of independence at departmental level. EUC appears therefore to be increasing in status as an important element in improving administrative productivity at Stanford.

3. Organization for Computing Management

The organization to manage computing at Stanford has undergone several changes in the past decade. Indeed, it is only in the last 10 years that a management structure has been established to control and rationalize the explosive growth of computing power and applications throughout the university.

Administrative and academic computing developed separately in Stanford. The administrative side was centered on a batch and then the timesharing mainframe environment that exists today - centralized data, processing and control, with little processing power in end-user hands. The overall central organization was known in the 1960s and 70s as the Stanford Center for Information Processing (SCIP) and by the late 1970s as the Center for Information Technology (CIT) and by yet another title change to Information Technology Services (ITS).

Academic computing grew as each department bought machines for its own needs. The result was described in a recent article on Stanford computing [Ref. 33:pp. 180-181] as:

> an electronic Tower of Babel, with most of the departments' computers unable to talk to the other departments' computers.

Stanford staff agreed with the following quotation from the same article as typifying the situation in the late 1970s/early 1980s, but in relation to academic, not administrative, computing:

> In the late 1970s, the process was exacerbated by the introduction of personal computers. Stanford and other universities probably saw the power in desktop computing before most businesses did, and the result was that computing was distributed earlier and wider than at most businesses. Suddenly individuals had power, generating or manipulating their own databases, doing their own things. By 1980, the university was spending $40 million a year just for document handling, word processing, and text processing.

> Still the giant mainframes...continued to handle most of the computing. Video display terminals replaced the punch card rooms and the TTYs, but a great many people on campus were finding the big IBMs increasingly irrelevant.

Changes in the computing power structure and evident dissatisfaction of academic departments with CIT control led the Stanford top management to split university computing into two parts, with administrative remaining under CIT as a mainframe environment, and with academic under a new organization called Academic Computing and Information Systems (ACIS) [Ref. 33:p. 181]. Regrettably ITS (as CIT had by then become) did not accept the change and a power struggle began with ITS attempting to re-establish: "pre-eminence in all non-research information processing." [Ref. 33:p. 181]. This struggle was expensive and culminated in a $1 million deficit for ITS in fiscal year 1986, which was enough to cause direct intervention by top management. Stanford's Vice President for Business and Finance, William Massey, was quoted [Ref. 33:p. 185] as saying that the time had come, in the summer of 1986:

> to reunite what many of us felt should never have been rent asunder in the first place, academic and administrative computing.

A new organization, Information Resources (IR) was formed to recombine ITS and ACIS, to reduce computing management overhead, to focus attention on end-users, to develop a rational, unified strategy for departmental

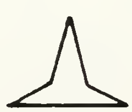
computing at Stanford, and to cause that strategy to be implemented.

The new IR structure recognizes departmental administrative end-users as a significant component of Stanford computing, certainly as significant as the greater population of faculty and students, who have generally been well served in the past. Professional support staff, previously centralized in the ITS environment, are being re-assigned to departments and schools where they can better develop new local administrative systems and where the need for better connections between departmental and central systems can be more readily appreciated [Stanford: Ref. 3].

Support staff decentralization can be represented in Figure 10 below by the variable aspect triangle, in the same manner as Figure 9 of the Aetna case. The central staff has been reduced and end-user area staff increased. Overall staff levels remain constant. However, resources are better used overall. In this case EUC instigated structural change. The presence of EUC was the single reason for placing IS support staff in the field.

Figure 10

Differentiation Structural Impact of EUC



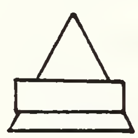
the variable aspect triangle, representing de-centralization of support to the EUC area.

Re-centralization of computing management has catalyzed the appearance of new multi-departmental Teams for Improving Productivity at Stanford (TIPS), representing an increasing proportion of the end-users in 170 departments, which are attempting to overcome years of departmental computing insularity [Stanford: Ref. 2]. TIPS started as an informal group of end-users from a variety of departments, both administrative and academic, who were unhappy with the lack of exploitation of microcomputers on campus. Their view was that localization of many centralized information processing tasks would improve departmental productivity. The advent of this informal group was very timely and it became more visible during the changeover from the ITS/ACIS environment to IR. Recognized as a potentially important source of input to development of future end-user systems, TIPS was formally chartered in 1987 with a high-level governance group with membership from all aspects of IR management as well as from user groups. The TIPS governance group is starting to prioritize system investigations and development work by working parties which are made up of end-users and departmental IR staff (noted before as having recently been decentralized to the field). The TIPS governance and working groups appear to provide the best opportunities yet for registration of user requirements and to give end-users more effective avenues to share their growing experience.

As in the CMC example reflected in Figure 6, addition of the TIPS governance and working groups can be represented by a stepped pyramidal shape, as in Figure 11 below. Need for EUC support has instigated creation of these new organizational elements - represented again by a rectangle as they are not themselves necessarily hierarchical in nature. The overlap of the TIPS rectangle on the previous triangle reflects the reality that the overall computing management organization is different with the addition of TIPS.

Figure 11

Differentiation Structural Impact of EUC



the stepped pyramid, recognizing insertion of a new layer of organization to support EUC.

While the example of TIPS gives evidence of steps being taken to create more vertical and horizontal communication within the community of Stanford end-users, the conflicting power, cultural and business positions of the institutional 'establishment' will perhaps continue to constrain organization-wide alignment of strategic policies with the needs of departmental end-users for some time to come.

4. <u>Information Processing</u>

The new IR structure at Stanford recognizes increasing overheads in expensive central facilities which users, having access to cheaper localized local facilities, are less willing to use. Top management in the university has made a strategic commitment to departmental information processing and has recognized that decentralization of processes will inevitably involve changes in power structures. Ownership of data and adherence to centralized procedures is becoming more of an issue in EUC. Over the past two years many discussions have been held to rationalize inefficient procedures in the Stanford mechanized procurement system. Effectiveness of the computer-based system was distinctly compromised by the necessity for all procurement to be expressed on paper which could then be signed by an authorized officer. End-user departments fought hard to substitute electronic authentication of procurement, and recently received approval to incorporate this technology. A pilot program is now starting to achieve as close to 'paperless' internal procurement procedures as possible. End-users will be able to obtain procurement authorization on-line. This will reduce the number of administrative layers involved in the procurement process, in clerical areas of forms control, printing and distribution, as well as in the approval area [Stanford: Ref. 2].

This initiative is an example of improved information processing, through EUC technology's instigation of change in organizational processes and structure. In this case, end-users saw the need for automated procurement approval as a key factor in enhancing the productivity improvements made possible by screen-based forms entry and communication of the these forms via local area network. If electronic records had to be output to paper in order to obtain an authorizing signature, the productivity gains of data entry and communications would have been compromised.

This expected reduction in administrative layers can be represented by a flat triangle in the same way as for the Aetna example Figure 7. Substitution of manual procurement methods at Stanford through EUC automation is only one example of many such improvements that may be achieved in future.

Figure 12

Information Processing Structural Impacts of EUC

the flat triangle, recognizing reduction in hierarchical levels through automation of manual tasks by EUC.

Access to centralized institutional databases is at present highly controlled and most access is read-only, even though institutional information is an aggregation of data generated at departmental level. There is as yet no general

allowance for administrative end-users to write direct to central files. Therefore links between new departmental administrative systems and mainframe systems are often used only to download data from central databases. Return of updated departmental data to the central database requires re-formatting to central requirements, printing out and hand carry to a central input point, where it is re-keyed as authorized update to the central database. The inefficiencies of this methodology are well recognized, and a slow process of amending the traditions of data ownership has commenced. Such visible rebuilding of power relationships will not achieve its objectives quickly.

Stanford IR staff do not see any significant changes to formal departmental structure in the near future [Stanford: Ref. 3]. The belief is that end-user technology will eventually force decentralization of processes, data and therefore control, but the loose coupling of the varied elements of the Stanford organizational structure will remain a strong factor, and therefore reductions in information processing efficiency can probably be expected in the short to medium term when compared to that existing in centralized systems today.

The EUC applications now being developed in administrative groups are of two types:

- standalone, microcomputer databases of local information, e.g., for student and financial administration;

- microcomputers being operated as intelligent mainframe terminals, with the capability to capture data documented from the central mainframes and to manipulate this data to suit departmental requirements.

While individual departments are gaining greater control over their own affairs through localized processing, they remain significantly constrained by their inability to return information to central databases outline [Stanford: Ref. 2]. This appears to be a principal reason why administrative organizations are remaining structurally static. Until departments can achieve greater total computing autonomy, there will be considerable overlap of the microcomputer-based departmental systems and the older mainframe-based systems, the latter being the computing basis for the present structures. In this sense, the presence of EUC is emphasizing that structural changes can be made to improve the way departments do business. However, other higher-level changes in authority relationships, not specifically related to computing, need to be made before EUC and departmental structures can be aligned.

5. <u>Differentiation</u>

Senior IR managers and end-users at all levels appear to agree that the re-centralization of IS management at Stanford has been a good move. More coherent management of administrative and academic computing has reduced horizontal differentiation at high level, and has removed

one vertical organizational level. However, this might be seen as resolution of a general management problem not necessarily attributable to the existence of EUC alone.

The integrating TIPS governance and working groups have added an EUC-related layer to the IS management structure, and there is potential for formal implementation of departmental Information Centers to add yet another level in the future. The TIPs layer may only be temporary, remaining until other levels such as the ICs achieve maturity.

The layers of both formal and informal structure inherent in the Stanford culture will perhaps become more visible as each department lays out its perceived rights to local ownership and processing of its own administrative data. The end-user prototype system now under test in the Law School has pointed out several duplications of effort between the school and central student administration [Stanford: Ref. 2]. Opportunities are therefore appearing to reduce administrative staffing in some central areas, releasing them for other duties in departments which are not well staffed. This is an opportunity offered by EUC which is recognized, but which is some way from full exploitation.

The desire for administrative departments to decentralize their computing systems is growing for the following reasons:

- motivation to overcome problems of centralized ownership of data by setting up local databases more supportive of departmental end-user requirements;

- with increasing costs of mainframe computing (even with recent chargeback reductions), departments prefer to set up their own data systems, passing their results off-line to a mainframe entry point for update of the central institutional database. (While this is an inefficient use of computing resources, it is financially more reasonable for the department.)

So, if a department can exert more control over its own affairs through localized end-user computing, then it will do so. In the past, minicomputers were expensive, therefore administrative processes at departmental level were peripheral to the academic use of these machines. Microcomputers now make the local processing option more viable. This trend to departmental systems brings specialized needs for flexibility, for tailored applications and, most of all, for the autonomy that central systems are unable (and, in fairness, were never designed) to meet.

The visible need of end-users for more direct local support has catalyzed relocation of professional systems analysts and programmers from their previously central positions in the old ITS organization to the departmental level. This may have seemed appropriate when considering the needs of non-professional computing end-users. However, the action has taken a single, cohesive group, with all its attendant career, cultural integrity and professional visibility, and has broken it into smaller and less definitive teams. Already there are signs [Stanford: Ref 3]

that the computing professionals feel isolated in their unfamiliar new locations, that they cannot control setting of priorities as well as previously, that they feel cut off from developments in Stanford computing as a whole, and that they feel their career horizon has been reduced to that of a team rather than the previous department. If not resolved, unhappiness in the ranks of these computing professionals could have deleterious effects on the work to develop and improve departmental end-user systems. Stanford appreciates this problem but as yet has developed no solution that meets both the needs of the end-users and their support staff [Stanford: Ref. 3]. This is one example where structural re-alignment to meet the needs of EUC may not have been the best solution, although with less than one year's experience of the change, it may be too early to be definitive.

Stanford IR managers were asked for their views on expansion of the IR management structure to accommodate increased depth of system development tasks, to work on reorientation of data ownership and to direct the eventual implementation of a coherent distribution of process data and control. The response was that such an increase in horizontal differentiation was desirable, but that the new IR organization had not yet developed to the extent that the resulting increases in span of control for the existing managers could be accommodated [Stanford: Ref. 2].

6. <u>Communications networks</u>

Networking arrangements at Stanford are now addressed in some detail to provide a clear background to the Stanford's emphasis on communications between diverse work groups, individuals and the databases that serve them.

a. The Stanford Network (SUNet) - brief overview

A gift from Xerox in 1978/9 of an experimental local area network (LAN) and associated workstations commenced the networking move away from timesharing. By 1981, the need for campus-wide networking had been clearly established, and wider linkage to other external academic networks was becoming urgent. SUNet has grown to today's complex mesh of 70 interconnected LANs, which provide network cabling to a department's door, there to be connected to departmental administrative and academic systems [Stanford: Ref. 4].

b. The strategic need for networking

Studies of administrative computing have shown wide variation in the approaches taken throughout the university to support similar tasks and functions. IR managers reported during this study that a primary impetus for SUNet has been to enable end-users at all levels - institutional, departmental and individual - to be able to talk to each other electronically, to share systems, to transfer files and, through these actions to progress toward greater processing commonality. The point was made that:

as more of our office information needs become independent, it becomes more necessary to insure that the connections between these different approaches supports the clear and uninhibited flow of essential information. [Stanford: Ref. 4]

The view of networking strategists is that, if departmental systems do increase, as both end-user pressure and overall university policy would support, electronic communication will be the determinant of successful aggregation of departmental data at institutional level. A major concern of the trend to de-centralized databases is that coherence of data now held in central mainframe files will be diluted. Issues of data entity management, commonality of processing procedures and end-user education and training are being openly discussed as a direct result of SUNet's ability to make distribution of institutional systems to departmental level a practical possibility. SUNet provides facilities to connect diverse end-users, but recognizably diverse they remain. Without changes in the power and cultural makeup of Stanford, this study suggests that truly distributed computing across the whole of the administrative end-user environment may not be feasible.

The point was made during discussion that the policy of greater departmental EUC was not to achieve improved data processing efficiency [Stanford: Ref. 5]. Rather the policy recognized the need for improved departmental efficiency through greater operational autonomy. The responsibility and ultimate utility of

computer networking is to make connection between groups easy and as error free as possible so that departments will not repeat the insularity of the past but develop more cooperative operations where it is in their interests to do so. The network is neutral, because s it supplies only communication paths. However, it is still up to users to provide the applications that will use the network.

SUNet provides improved velocity of communication between groups at Stanford by providing alternative informal paths for information that did not exist before. This support for informal structure was a property of EUC also recognized in the CMC study.

There is a suggestion in Stanford that, if electronic communication does indeed become a long-term element of institutional, departmental and individual interaction, then the resulting interpersonal networks can do more to change the power and cultural barriers to changes in administrative computing than more classical management initiatives.

8. <u>Summary</u>

The following Table 6 summarizes the strategic position of EUC as observed in Stanford, and the structural impacts noted in the course of this study. As with the previous CMC and Aetna cases, these findings are further interpreted in Chapter V.

TABLE 6

ENVIRONMENT OF EUC AND ITS STRUCTURAL IMPACTS AT STANFORD

Strategic policy	:	EUC is a major focus of computing management. Controlled growth of low-level EUC in concert with expansion of LANs and backbone network.
EUC status	:	Widespread; older timesharing technologies still in use. Changing from centralized to distributed processing. End-users still in conflict with centralized power groups, but developing own political power.
Impacts noted		
Information Processing	:	Reduction in approval layers (Figure 12) [F]
Differentiation	:	Decentralization of IS resources (Figure 10). [I] New EUC support layers (Figure 11). [I] Re-centralization of previously divided MIS management (partly due to EUC).
Communications Networks	:	Network provides opportunities for departmental EUC as opposed to timesharing on mainframe. [F] Support distribution of data and decentralization of administrative systems. [F]

Legend:

EUC instigates [I] or facilitates [F] structural change.

E. SUMMARY OF THE RESULTS OF THE THREE CASE STUDIES

In Chapter III, four specific aspects were noted as being covered during the case study interviews of CMC, Aetna and Stanford:

- the strategic policy of the organization regarding EUC, and the status of EUC in the organization;
- an assessment of the degree of application of computing tools by the end-users in each organization;
- movements in organizational structure over the past five years, and whether EUC instigated or facilitated these changes, and
- the impacts of EUC on the structural variables of information processing, differentiation and communications networks, introduced in Chapter II.

These four aspects are again addressed in tabular form to provide a summary of the results already provided at the end of each case. The Tables 7,8 and 9 below provide an avenue to compare the situations of each organization in a single view. The answers to the third and fourth questions were combined during the presentation of results for each organization, and therefore this summary will follow the same format as was given in Tables 4,5 and 6 for CMC, Aetna and Stanford respectively.

TABLE 7 STRATEGIC POLICY AND EUC STATUS IN EACH ORGANIZATION			
	CMC	Aetna	Stanford
Strategic Policy regarding EUC	EUC is an integral part of the CMC operating environment. Controlled growth to improve spans of control and to meet end-user needs	EUC is a primary element of corporate strategy. Accelerated growth under deliberate implementation plans.	A major focus of computing management. Controlled growth of low level EUC in concert with expansion of local area and backbone networks.
Status of EUC in the organization	Widespread and modern, with EUC systems integrated into the operating environment. End-users appear to possess some organizational power.	Widespread, and modern, with EUC the primary force for change in the organization. End-users are changing from clerical to information technology duties.	Widespread, older timesharing technologies still in evidence. Changing from centralized to distributed processing. End-users still in conflict with central power groups, but developing power of their own.

TABLE 8 USAGE OF COMPUTING TOOLS IN EACH ORGANIZATION			
	CMC	Aetna	Stanford
Degree of application of computing tools by end-users	. Mainframe, midrange and microcomputer hardware. . The full software range. . Widespread networking.	. Mainframe, midrange and microcomputer hardware. . The full software range. . Widespread networking.	. Mainframe and microcomputer hardware. . Emphasis on word-processing, spreadsheets and DBMS. . Increased networking.

TABLE 9

IMPACTS OF EUC ON STRUCTURE - LISTED BY STRUCTURAL VARIABLE

Variable	CMC	Aetna	Stanford	Symbol
Information Processing	Channels of information flow. [I]	Channels of information flow. [F]		
	Increased spans of control [F]			
		Extension of formal organization with an informal one. [F]		
		Reduced hierarchical levels through automation of manual tasks. [F]		
		Linking of one formal organization to another. [F]		
		Planned staff reductions. [F]		
			Reduction in approval layers. [F]	
Differentiation	Increased spans of responsiveness. [F]			
	New EUC support layers [I]	New EUC support layers [I]	New EUC support layers [I]	
		Decentralization of IS resources. [I]	Decentralization of IS resources. [I]	
		Displaced clerks become information technologists. [F]		
			Re-centralization of previously divided IS management (partly due to EUC).	
Communications Networks	EUC networks enhance informal structure and, in turn, make formal structure more effective. [F]			
		Networks enhance formal organization. [F]		
			Supports distribution. [F]	

Legend: EUC instigates [I] or facilitates [F] structural change.

V. FINDINGS

A. USE OF THE RESULTS OF DIRECT RESEARCH

This study has viewed three administrative organizations, CMC, Aetna and Stanford. The impacts of EUC on organizational structure discovered through these case studies have been summarized in Table 9 of Chapter IV. The primary purpose of this Chapter is to fulfill the aim of the case interviews by:

- testing agreement with, or variance from, previous research results;
- identifying impacts of EUC on organizational structure that may have not previously been recorded;
- explaining the variances discovered,

and presenting these interpretations in the context of the research questions posed in Chapter I. This structured process recognizes that this study, with its limited sample using principally anecdotal evidence, does not lend itself to generalized conclusions. The impacts presented in Table 9, together with the interpretations below, do however provide managers and researchers with a range of structural impacts to consider, either within the boundaries of this study alone, or as the basis for further investigations.

In addition, the following aspects are covered in this concluding chapter to elaborate on the research questions:

- the influence of corporate strategy;
- the influence of political and cultural variables;
- degree of EUC evolution, and
- visibility of the EUC horizon.

B. ANSWERS TO RESEARCH QUESTIONS

1. To what extent do organizational structures change when new information technology is introduced to end-users?

This study has shown that the introduction of new information technology to end-users in an organization may induce a tendency to organizational change. In the Aetna case, older end-user technologies, such as timesharing, are being overlaid by more contemporary microcomputer and networked environments. The power and potential commercial utility of new information technology has been recognized at Aetna, and the whole corporation is undergoing significant structural change under a strategy to exploit EUC where possible. At Stanford, recognition of EUC has brought the desire to improve information processing productivity. In turn, this has catalyzed formation of the TIPS user support group, whose name - Teams for Improving Productivity at Stanford - indicates the very effect sought as a result of new abilities available to end-users. Development of a more significant power base for end-users in Stanford is also leading to changes in relationships between various levels of the organization's hierarchy.

The extent of this tendency for change appears to be dependent on the strategic view of corporate management, on whether EUC is to be expanded and under what level of control. If the strategy is to apply the full capabilities of current information technology to EUC as quickly as possible then, as evidenced by the Aetna case, the tendency for change is widespread. If there are other organizational factors to be taken into account in addition to EUC alone, as in the Stanford situation, then the tendency is less pronounced. This study has shown that power, culture, resistance to change and extreme willingness to change, excitement at new possibilities, enhancement of old skills, external environmental factors all influence change in organizations. Therefore it appears that the answer to this research question must recognize the influence of these other variables.

2. <u>Does end-user information technology instigate structural change or facilitate it?</u>

End-user computing appears to both instigate and to facilitate structural change.

In the organizations studied, EUC instigated structural change when power, autonomy and control became issues, and when EUC elements required support. For example, CMC placed structural boundaries on data access in recognition of the way that EUC spreads significant information processing capability throughout an

organization. If not controlled, this capability could act against the power bases of the organization, as CMC found. As a further example, Aetna's move to interorganizational structure through linkage with its independent agents shows EUC technology leading change in structure. This could be interpreted as an exercise in organizational control, and is therefore not inconsistent with the CMC example. Where support was required for EUC, either by addition of organizational layers such as ICs (in all of the cases), or by decentralization of specialized IS personnel (in the Aetna and Stanford cases), the needs of EUC actually instigated the structural change.

In all other impacts noted in the course of the case studies, as shown in Table 9, EUC appears to facilitate structural change in organizations. These other instances were examples of management exploiting the productivity gains of EUC in various ways and, as a result, changing organizational structure to achieve what they saw as the appropriate gain from the EUC offering. In these situations, managers appear to have a wide range of options within the two extremes of changing structure in a significant way at one end or doing nothing at the other.

3. What are the impacts of EUC on the structure of contemporary administrative organizations?

This study has approached the answer to this primary question via three key variables: information processing,

differentiation and communications networks. Table 9 shows the impacts of EUC on the structures of the organizations studied, listed by these structural variables. The table shows a range of direct impacts in the areas of information processing and differentiation but, for communications networks, the impact of EUC appears to be somewhat more indirect, acting in support of the other variables. This may be in recognition of the neutral nature of networks themselves, providing facilities for other more active variables to affect structural outcomes, and is in accord with the organizational approach summarized in Table 2 of Chapter II.

There is general agreement between the case study impacts noted in Table 9 and the impacts suggested in the literature review in Chapter II. However, the three case studies have exposed several new impacts in the interorganizational use of EUC that show managers exploiting information technology in new ways (e.g., Aetna's use of remote 'kiosk' terminals to link their formal organization to the informal population of potential clients). These situations were from a single case study and therefore it is not reasonable to draw any generalizations from the observations other than to say that this use of EUC appears very effective for Aetna.

C. FURTHER ELABORATION OF RESEARCH QUESTIONS

1. The influence of corporate strategy

The Munro/Alavi models, discussed in Chapter II, suggested that the strategic view of EUC taken by a corporation could be significant to the impacts EUC could have on structure. Differing strategic views of CMC, Aetna and Stanford to EUC produced different approaches to its exploitation, and played a significant role in whether the degree of EUC impact was significant or slight.

The CMC position is one of controlled, relatively low growth of EUC and a degree of positive control to restrain the impact of information technology on higher priority personal strategies. Aetna sits at a point reflecting high expansion with some controls, but with a strong desire to give information technology as much chance as possible to succeed on its own merits. Stanford has a policy to expand EUC, but there remain significant controls on administrative system changes that are limiting the degree of expansion that the policies may espouse.

2. The influence of political and cultural variables

Table 9 shows that most structural changes have been variations to the classical hierarchical organization model. This of course recognizes the underlying power and cultural realities of people in organizations. While in theory organizations exist to achieve the goals of their leadership, they also fulfill the personal desires for

achievement and personal interaction that are ingrained in all of us. Therefore no significant departure from the mechanistic form of the hierarchical organizational form was expected in the large organizations studied.

There were definite variations in the political and cultural bases of CMC, Aetna and Stanford. These influences could not be isolated entirely from the direct EUC influences. In CMC, the corporate political climate is benign but pervasive. It is integrated into the culture of primacy of CMC's people, and the corporation has on occasion acted to prevent information technology form interfering with its formal structure. Aetna is different to CMC in that its management has determined that information technology is the key to future corporate success, and EUC technology has been embraced openly. Positioned somewhere between the other two organizations, Stanford has an environment of strong central power with diversified cultural patterns. In this situation, it has been difficult for strategic planners to accelerate the growth of EUC, even though an overall goal of EUC expansion exists. With an imbalance of political, cultural and informational technological forces at Stanford, it is not surprising that the new de-centralizing moves in EUC have to date resulted in only minimal impact on structure.

This is not to lessen the value of the results obtained in these case studies, but to emphasize that they

may not have been due always to EUC alone. This problem will be addressed later as a possibility for further research.

3. <u>Degree of EUC evolution</u>

The differences between the organizations appeared to be emphasized by variations in the present momentum for EUC sponsored change exhibited by each. Review of the evidence and the advice of prior research suggested that the degree of maturity, particularly of the newer EUC technologies might also have an influence on corporate strategic view of EUC as a catalyst for structural change. This approach recalls the comments on technology overlays made during the discussion of the Nolan model [Ref. 11] in Chapter II. With the present pace of technological refreshment in corporate administration, there appears little opportunity for a single technology to take effect before a new technology arrives and overlays it.

In Stanford, for example, the mature end-user environment of centralized mainframe timesharing has been overlaid by significant developments in communications networks. In turn, the availability of cheap microprocessors is catalyzing significant expansion of departmental systems, first as standalone and then as networked environments. Individual departments are developing their own systems to improve the efficiency preparing local inputs to central systems. With all of

these technologies developing at different rates from different origins, stability may be a long way off.

4. Visibility of the EUC horizon

This thesis has shown that end-user computing is a complex interaction of information technology, organization structural and people-related variables. The technology itself is expanding rapidly and the computing power being made available to end-users, in both hardware and software, is constantly increasing. While the definitions of EUC in Chapter II provide a sound initial view of the subject, it appears that the boundaries of EUC vary from one organization to another, and that their dimension is not clear. There do not appear to be simple answers to questions of the future impacts of EUC on organizational structure, and there is ample opportunity for more research.

D. SUGGESTIONS FOR FURTHER RESEARCH

This study has shown how diverse is the population of factors affecting EUC impact on organizational structure. Two axes for further research are suggested to improve understanding of the coupling between EUC and structure, and to move toward the development of new organizational models that specialize on these two aspects alone, rather than as part of a larger matrix of variables.

1. Controlled experiments building upon this study

While EUC has been seen to be a factor in changing the structure of administrative organizations, neither the results of this exploratory study nor other research establish clearly the impacts of EUC alone. That is, it has been difficult to isolate EUC from all other factors that might impact on the evolution of an organization's structure.

Therefore, one avenue of further research may be to perform a series of very controlled examinations, to isolate factors other than EUC and to keep them constant during the period the EUC variable is being studied. The difficulty of this approach should not be under-estimated. Many of the interpersonal factors affecting organizations - such as those resulting in cultural and power shifts - are not necessarily visible while they occur, and become apparent only by their effect. A longitudinal study might be appropriate in these circumstances, where changes are followed over time, and where the relationship between cause and effect may become more visible.

Viable new organization structural models are needed to help managers to assimilate and use EUC better, and there appears to be a strong case for such controlled research.

2. Investigate layers of computing technologies

This study recognized that multiple layers of computing technologies now exist in an organization at any

one time, and that the degree of assimilation of these technologies. It is therefore not unreasonable that the influence of these technologies on end-users will vary with the degree of assimilation of each technology. The assimilation model of Nolan [Ref. 11] is now nearly 20 years old and appears no longer able to support the full range of activities now possible in today's intensive information processing environment.

A study of the differing organization structural impacts of various levels of end-user hardware and software would appear to be worthwhile, particularly if varying rates of assimilation were also taken into account. While such a study would undoubtedly be complex, it may provide significant insight into the connections between the technology itself, its relative maturity and the matrix of options for EUC exploitation that are available to organizational strategists.

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